4.4 Case study 4 (CS4 Slovakia)

Concept focus	Neutral solutions, neutralisation reactions
Activities implemented	Activities D-E
Inquiry skills	Working collaboratively (communication skills)
Scientific reasoning and literacy	Scientific reasoning (addressing problem through logic and use of evidence, forming conclusions)
Assessment methods	Classroom dialogue Self-assessment Worksheets
Student group	**Grade:** 8th grade (lower second level chemistry class) **Age:** 14 years **Group composition:** co-ed (18 students), groups of 3-4 **Prior experience with inquiry:** One previous experience (**CS3**)

In this case study, students investigated salts and neutralisation. The students were asked to explain two key observations; first, the indicator did not change its colour in solutions of powdered chalk and kitchen salt and secondly, mixing of an alkaline and acidic solution created a neutral solution. The teacher evaluated students' responses to assess their *scientific reasoning* capabilities. Skill in *working collaboratively* was self-assessed, using the assessment tools from the original unit.

(i) How was the learning sequence adapted?

The teacher chose two activities from the **Acids, bases, salts** SAILS inquiry and assessment unit for implementation. First, Activity D: Identifying salts, was implemented without modifications. Students were already familiar with the function of indicators from their previous inquiry-based activities. During this activity they observed that the indicator does not change its colour in solutions of powdered chalk and in solution of kitchen salt. They were asked to explain this phenomenon. The teacher modified Activity E: Acids dissolve salts, bases dissolve fats, considering the aim of the activity – to observe and describe neutralisation. It is appropriate to implement the original experiment into teaching of the topic *Solubility of substances*. The teacher expanded the activity with neutralisation; students mixed acidic and alkaline solutions and observed the phenomena accompanying this experiment. To motivate and stimulate students, the teacher used the following open questions:

- Why are the water solutions of chalk and salt neither acidic nor alkaline?
- What is the pH value of chalk and salt solution?
- How many groups of substances do we know according to the pH scale?

The chosen activities were realised in a class of 18 students – 8 boys and 10 girls. The class is composed of very clever students, but also of average students, students from disadvantaged backgrounds and students with behaviour and learning disorders. All students worked individually on the tasks in the worksheet.

(ii) Which skills were to be assessed?

The activities were used to assess *scientific reasoning* (addressing problem through logic and use of evidence, forming conclusions). This skill was assessed through analysis of students' answers in their worksheets. *Working collaboratively* (communicative skills) was evaluated by students' assessment table (using a Likert scale). In this assessment, the teacher compared students' opinions about individual work and group work.

Gender was not taken into account. Boys and girls had the same tasks in worksheets. Students independently dealt with the tasks in the worksheets and practical activities. Assessment of skills was realised after inquiry-based activities were completed.

(iii) Criteria for judging assessment data

Scientific reasoning

Data were evaluated according to the following criteria:

1. Evaluation of a scale questionnaire about understanding of the observed phenomena
   a. Hypothesis 1: Explanation of the fact that the indicator did not change its colour in solutions of powdered chalk and kitchen salt
   b. Hypothesis 2: Explanation of the fact that mixing of an alkaline and acidic solution creates a neutral solution
2. Evaluation of students' answers to assessment of group work and individual work.

Based on the English version of the material, the teacher prepared a tool for verification of explanation of observed phenomena during inquiry-based activities (Figure 1). This was used for testing of hypotheses 1 and 2, and assessing the students' ability to reason. Figure 2 shows the results of hypothesis testing.

Hypothesis no. ___

The mistake was:

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The final conclusion is:

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Verified ☐ Modified ☐ Rejected ☐

Figure 1: Self-assessment of hypothesis formulation

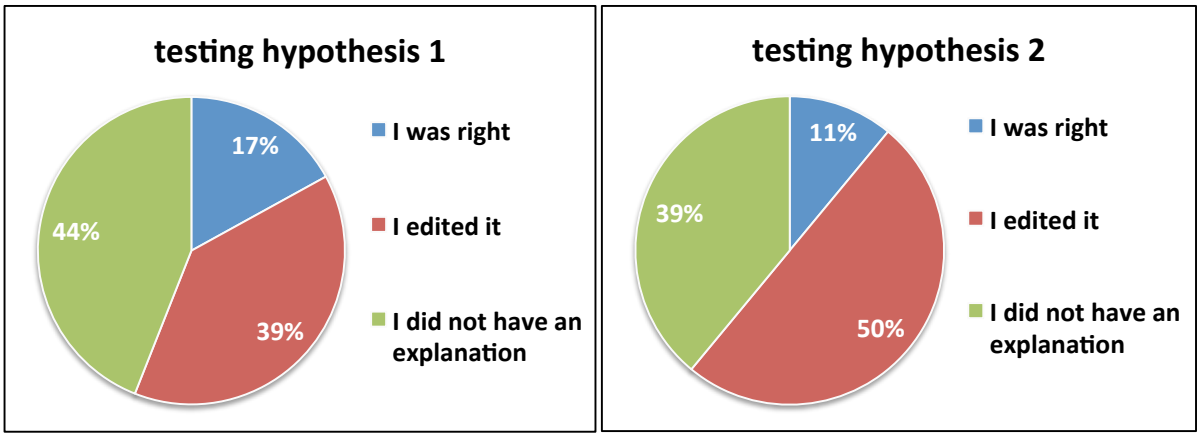


Figure 2: Analysis of results for testing of hypotheses

Testing hypothesis 1: Explanation of the fact that the indicator did not change its colour in solutions of powdered chalk and kitchen salt

Task: In the first experiment, based on the observation, students were supposed to explain why the colour of indicator did not change after it was added into solutions of powdered chalk and kitchen salt.

Correct explanation: Indicator (red cabbage extract) changes its colour only in acidic and alkaline solutions. In neutral solutions, the original colour – purple does not change.

Figure 2 shows that only 17% of students were able to explain the observed phenomena. Up to 44% of students were unable to describe what they had observed and 39% of students did not write any explanation.

Testing hypothesis 2: Explanation of the fact that mixing of an alkaline and acidic solution creates a neutral solution

Task: In the second experiment, students dripped acid solution (vinegar) into alkaline solution (soapy water) in the presence of the red cabbage indicator. The indicator changed its colour to the colour of a neutral solution. Based on the observation, students were asked to explain why the indicator changed its colour in alkaline solution after adding acid solution.

Correct explanation: By mixing of alkaline and acid solutions we get a neutral solution. The proof is the colour of the indicator (red cabbage extract), which changes its colour from blue or green to purple – which is the original colour of the indicator.

As shown in Figure 2, only 11% of students were able to describe the observed changes correctly. One of the reasons for this low rate of success is that students worked individually and they were not sure at formulation of conclusions. Also, it was their first experience with inquiry-based tasks. It was difficult for them to find the analogy only after one observation of colouring of the indicator.

Working collaboratively

Verification of communicative skills was realised using assessment tables (as detailed in the unit), which were filled in by students after the inquiry-based activities. Assessment of group work (Table 1) and assessment of individual work (Table 2) were analysed separately for clarity (Figure 3).

Table 1 shows that up to 57% of students prefer group work and only 16% of students do not like it. During group work, up to 39% of students are more assured always or sometimes. 66% of students prefer group work, because they think they would not manage to fulfil the task on their own. Up to 62% of students can always listen to ideas of others, but only 39% of students can persuade others about their ideas. An important conclusion is that up to 51% of students think that they learn more during group work. Results of assessment of students´ communicative skills during the group work are shown in the corresponding graph (Figure 3a).

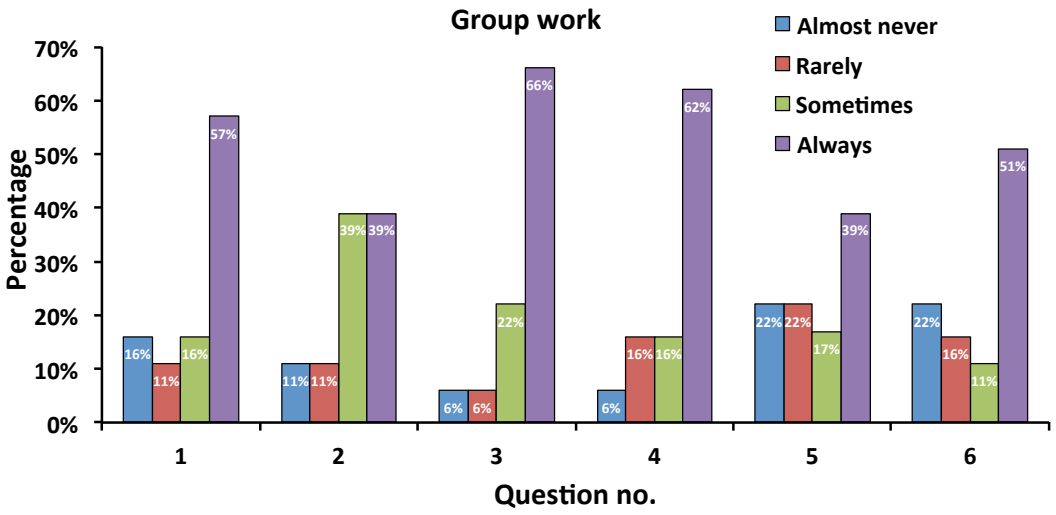
Table 1: Assessment table for working collaboratively (teamwork)

Use the following scale and mark the option which describes you most:	almost never	rarely	sometimes	always
1. I like to work in a group.	**16%**	**11%**	**16%**	**57%**
2. Group work is more assuring than working alone.	**11%**	**11%**	**39%**	**39%**
3. I like working in a group, because I would not manage the work on my own.	**6%**	**6%**	**22%**	**66%**
4. I can listen to ideas of other members of the group.	**6%**	**16%**	**16%**	**62%**
5. I can persuade the group about my idea.	**22%**	**22%**	**17%**	**39%**
6. I learn more during group work.	**22%**	**16%**	**11%**	**51%**

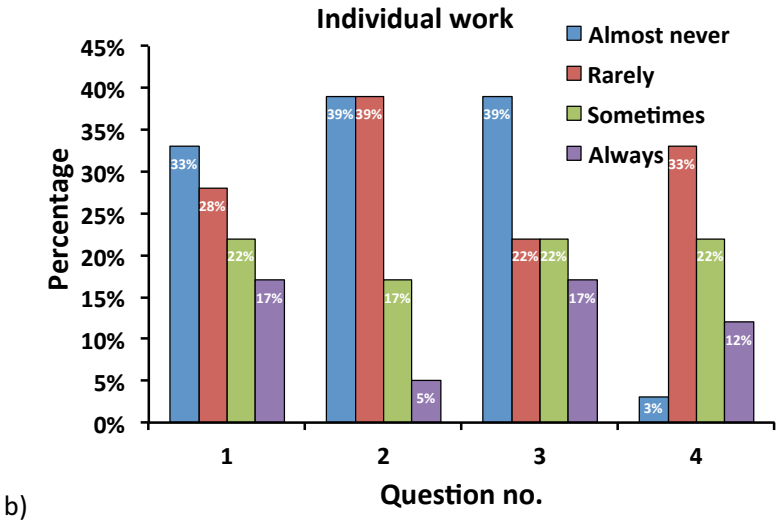
Looking at the results for the self-assessment of individual work in Table 2, only 17% of students always prefer working individually, only 5% of students think they learn more and 17% of students see the advantage of individual work in their own working pace. Different opinions are not the reason to prefer individual work. When we compare group work and individual work, students highly prefer group work, because it gives them the opportunity to persuade others about their ideas and to argue. It also gives them the inner assurance, which motivates them to work on the prepared tasks. In groups they can do better and they can divide the tasks.

Table 2: Assessment table for working independently

Use the following scale and mark the option which describes you most:	almost never	rarely	sometimes	always
1. I like to work individually	**33%**	**28%**	**22%**	**17%**
2. I learn more during individual work	**39%**	**39%**	**17%**	**5%**
3. I like my own pace during individual work	**39%**	**22%**	**22%**	**17%**
4. I prefer individual work, because the group does not accept my opinions.	**3%**	**33%**	**22%**	**12%**



a)



b)

Figure 3: Analysis of self-assessment of group work and individual work

(iv) Evidence collected

Teacher opinion

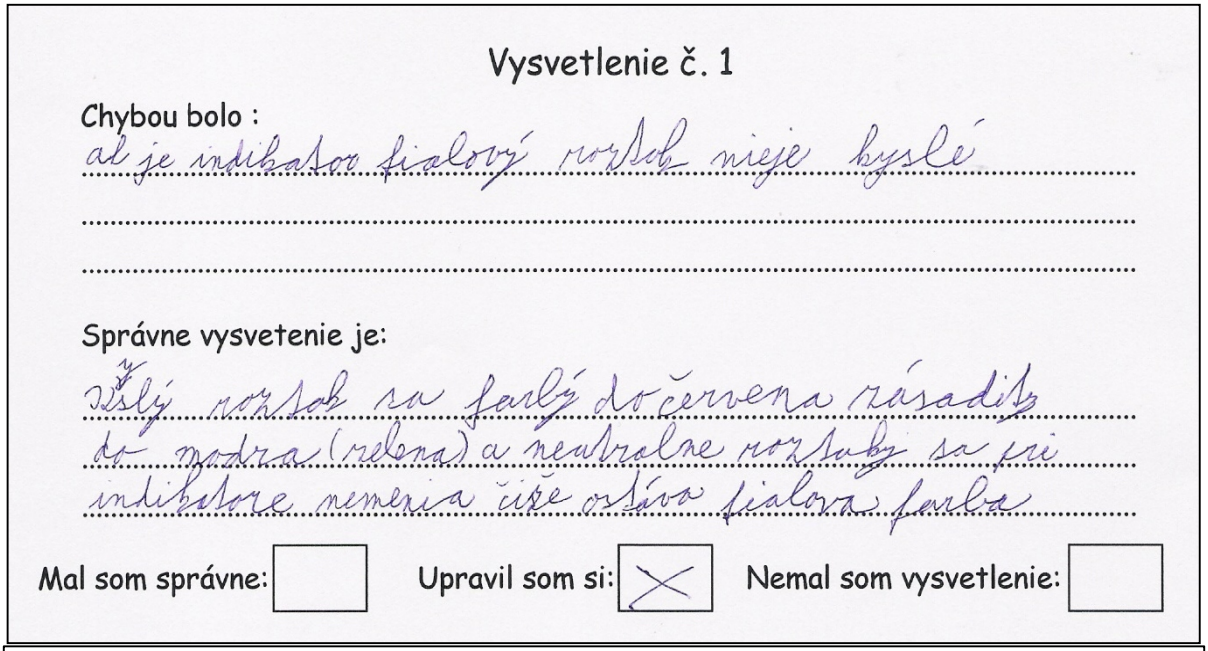
I expected low results in reasoning and formulation of conclusions, because students did not have experience with inquiry-based activities and I was right. Students managed these skills only with my significant help. Despite this problem, students´ reactions were keen, inquiry was appealing.

From a teacher´s perspective, I think that inquiry-based activities are beneficial for development of understanding of the phenomena observed during experiments. At the same time, practical, communicative and social skills are being developed.

Sample student artefacts

Teacher modified the template for testing hypothesis for use in verifying explanations. Some examples of student work and teacher evaluation are shown.

Example 1: Student´s explanation was incomplete, because he classified substances with purple and red colour into the same group – acid solutions. In the sample, he edited his answer and wrote down the correct explanation.



Vysvetlenie č. 1

Chybou bolo :

ak je indikátor fialový roztok nieje kyslé

Správne vysvetlenie je:

Kyslý roztok sa farbí do červena zásadité do modra (zelena) a neutrálne roztoky sa pri indikátore nemenia ciže ostáva fialova farba

Mal som správne: ☐ Upravil som si: ☒ Nemal som vysvetlenie: ☐

Explanation n.1

The mistake was:

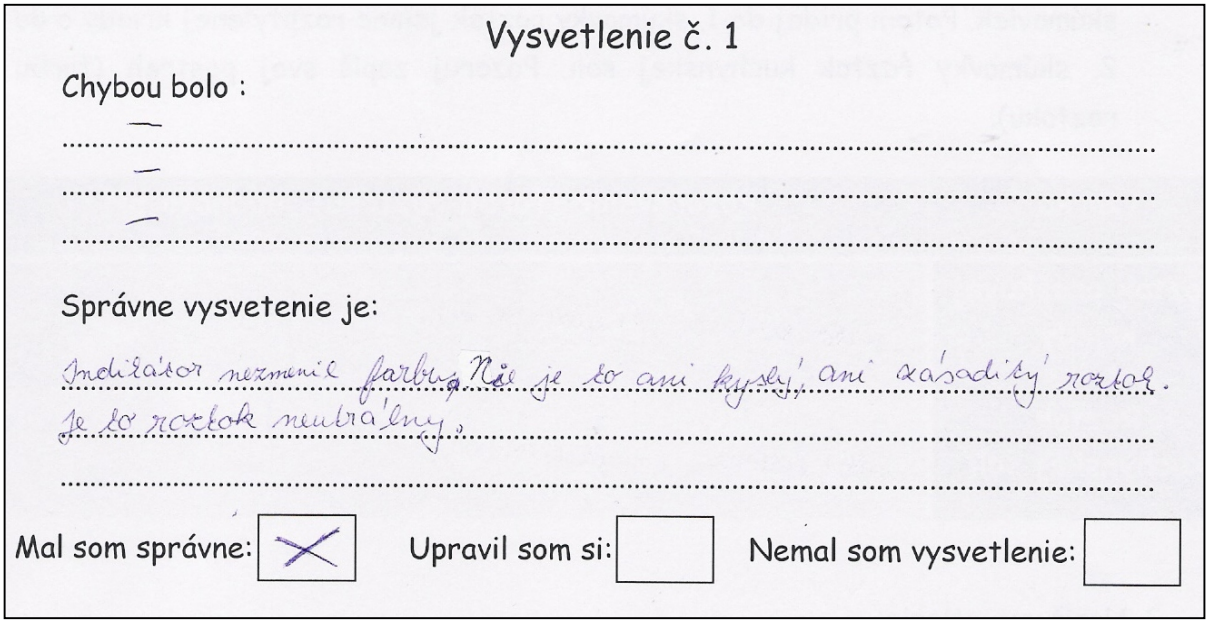
if the indicator is purple, solution is not acid

The correct explanation is:

Acids solutions colours red, alkaline colours blue (green) and neutral solutions do not change the colour with indicator, so the colour stay purple.

I was right: ☐ I edited it: ☑ I did not have an explanation: ☐

Example 2: In this case, the student did not have to edit her answer, because she was right. Based on the colours of the indicator, she understood the classification of solutions in 3 groups: acidic, alkaline and neutral. She explained correctly that if the indicator does not change its colour (stays purple), these solutions are neutral.



Vysvetlenie č. 1

Chybou bolo :

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Správne vysvetenie je:

Indikátor nezmenil farbu. Nie je to ani kyslý, ani zásaditý roztok. Je to roztok neutrálny.

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Mal som správne: ☒ Upravil som si: ☐ Nemal som vysvetlenie: ☐

Explanation n.1

The mistake was:

The correct explanation is:

The indicator did not change its colour. It is neither acid nor alkaline solution. The solution is neutral.

I was right: ☑ I edited it: ☐ I did not have an explanation: ☐

(v) Use of assessment data

Based on the verification of understanding of observed phenomena during inquiry-based activities, I found out that the biggest problem to students is to describe the observed phenomena and then formulate conclusions from their observations. Within the next lessons, I will be developing these skills. Results also showed that students are unable to create analogies during the observation of experiments in similar situations. On the contrary, students showed good skills in realisation of experiments, in group work communication and they appreciated innovations at experimentations. All the findings from the verification persuaded me about the importance to continue in inquiry-based activities.

(vi) Advice for teachers implementing the unit

Despite the initial failures in inquiry-based activities, I recommend to continue. The most difficult aspect for a teacher is to prepare sequence of tasks in the worksheet, so that the tasks are appropriately difficult and manageable. By preparation of several inquiry-based activities on different topics, even the teacher is improving several competencies associated with planning, preparation, realisation, management and assessment. Moreover, by using of various tools the teacher acquires self-reflection of own work.