4.5 Case study 5 (CS5 Slovakia)

Concept focus	How can chemists recognise an acid? Getting to know indicators
Activities implemented	Activities B-C
Inquiry skills	Developing hypotheses
Scientific reasoning and literacy	Scientific literacy (explaining phenomena scientifically, designing scientific inquiry)
Assessment methods	Classroom dialogue Self-assessment Worksheets
Student group	**Grade:** 8th grade (lower second level chemistry class) **Age:** 13-14 years **Group composition:** co-ed (25 students), groups of 3-4 **Prior experience with inquiry:** None

The teacher wanted to make students aware that acids are everywhere in everyday life, and not simply dangerous substances. The task "how can chemists recognise an acid?" was designed to allow students to measure the pH of common substances and laboratory acids. Students' skill in *developing hypotheses* and their *scientific literacy* were assessed, through evaluation of responses in worksheets and self-assessment.

(i) How was the learning sequence adapted?

People associate the term "acid" with danger. They often do not realise that acids are everywhere around us, they can be found in food (fruit, drinks, milk), washing and cleaning products, etc. This is what I wanted to show the students in this implementation. The activities are designed so that students cooperate in groups, ask questions, search for the answers, and learn to be responsible for the work which they are doing, as detailed in the teacher sheet (Figure 1).

Sample of a prepared activity

During the inquiry activity for the topic "How can chemists recognise an acid?" the students were provided with a worksheet (Figure 2 and Figure 3). They observed colour changes of indicators and they measured the pH of solutions of acids that are used at home and in the laboratory. They also consolidated the theoretical knowledge about the explored acids and they found out practical importance of usage of indicators. During the group work, students were asked to divide the subtasks, arrange the tools on the table, pour the examined samples into tubes, add indicators and record the observation process and formulate results of the inquiry.

The starting point of the inquiry was to understand the procedure in students' worksheet, its realisation and recording of the observed changes into a well-arranged table. Organisation of the inquiry was also very important – students had to be careful to not confuse samples and indicators. They also had to think about the time-management, in order to have enough time to clean up after the activity, fill in the worksheet and prepare for presentation of their results.

During the teaching I used these questions:

- What do you already know about acids?
- Where can we find acids in everyday life?
- Are these substances important for our lives?
- What is an indicator? What is it used for?
- What are the safety rules for working with acids?

- What should you do in the event of an acid spill?

(ii) Which skills were to be assessed?

During teaching I aimed at verification of development of the following skills: *scientific literacy* (explaining phenomena scientifically, designing scientific inquiry) and *developing hypotheses*.

How can chemists recognise an acid?

Learning aims:

- Explore acids used at home and in the laboratory,
- Get to know indicators as substances which are used to distinguish acids from bases and which are used to determine level of acidity of acids,
- Become familiar with the pH scale, which helps to determine the level of acidity of solutions,
- Get to know safety rules during working with acids.

Tools and chemicals:

lemon juice, vinegar, vitamin C pill, 10% solution of hydrochloric acid, 10% solution of sulphuric acid, 10% solution of nitric acid (teacher dilutes acids in advance), 6 beakers, 6 tubes, tube holder, litmus paper, universal pH papers, phenolphthalein solution, red cabbage extract, syringe

Suggestion of procedure:

Introduction: We revise students' basic knowledge about acids at home and in laboratory and safety rules of working with acids. To motivate students, we use dialogue, during which we ask open questions, such as "What do you think, how chemists find out if there is an acid in a solution?" or „Would you like to try out the task of chemists´ and get to know substances, which prove the presence of an acid in the solution?

Exposition: We divide students into groups of 3 or 4, we determine their workplace, distribute tools, chemicals and worksheet. Students formulate assumptions (hypotheses) and realise experiments according to the procedure given in their worksheets. They record their observations into worksheets, they cooperate during working, help each other, give advice, formulate hypotheses and conclusions. The teacher guides students during their work.

Fixation: At the end of the lesson, students clean up their workplace and one of the students in each group presents the results of their common work. At the same time, we are checking the answers in worksheet. Students should come to the conclusion that indicators are substances that change their colouring depending on the acidity of the surrounding.
For the feedback, we will use formative assessment in the form of student´s self-assessment card.

Questions for students:

1. Can you classify substances in the worksheet into two categories?
2. How would you call each of these groups with a common name?
3. Which group will explore which group of substances?
4. What do you think will happen with indicators?

Type of inquiry:

Guided inquiry

Features of inquiry:

Experimentation, formulation of hypotheses, observation, exploring of assumptions presentation of results, formulation of conclusions.

Figure 1: Teacher sheet detailing methodology for activity

How can chemists recognise an acid?

Tools: 6 little tubes, volumetric cylinders 25 ml (50 ml), funnels, droppers, syringes

Chemicals: lemon juice, vinegar, Celascon in water, 10% solution of hydrochloric acid, 10% solution of sulphuric acid, 10% solution of nitric acid, litmus paper, universal pH paper, phenolphthalein solution, red cabbage extract

Tasks:

1. Read the following procedure of work and try to formulate a hypothesis - an assumption about what will probably happen, when you add indicator into the solution of acid and write down your assumption

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2. Make experiments according to the given procedure, write down your observations into the prepared table and try to answer corresponding questions. At the end, compare your hypothesis with the result of your inquiry/investigation.

Procedure:

1. Pour 5 ml of lemon juice into first tube, immerse litmus paper, and write down its colouring into the prepared table.
2. Using separate tubes for each sample, repeat step 1 using vinegar, Celascon dissolved in water, hydrochloric acid, nitric acid and sulfuric acid.
3. Then, pour out the contents of the tubes in the sink and rinse the tubes with water. Repeat the experiment, but instead of litmus paper, use the universal pH paper and write down into the table not only the colouring of the paper, but also the pH value, which you find out from the colour scale, which is shown on the cover of pH papers.
4. Then, pour out the content of the tubes again and rinse them with water. Repeat the experiment, but instead of immersing pH paper, drip 2-3 drops of phenolphthalein solution into every tube and write down the colouring into the table.
5. Then, pour out the content of the tubes again and rinse them with water. Repeat the experiment, but instead of the phenolphthalein solution, add 1 ml of red cabbage extract with a syringe into each tube. Write down the colouring into the table.

Indicators/Samples	Litmus paper colour change of paper	pH paper colour change & corresponding pH	Phenolphthalein colour change of solution	Cabbage indicator colour change of solution
Lemon juice				
Vinegar				
Celascon (in water)				
Hydrochloric acid (HCl, 10% solution)				
Nitric acid (HNO_3, 10% solution)				
Sulfuric acid (H_2SO_4, 10% solution)				

Figure 2: Student worksheet, page 1

Observations

1. What was the colour of litmus paper in acidic surrounding (in acidic solutions)?

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2. What was the colour of the universal pH paper in acidic surrounding (in acidic solutions)?

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3. How did the phenolphthalein solution colour the solutions of acids in the tubes?

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4. How did the red cabbage extract colour the solutions of acids in the tubes?

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Questions

- Litmus paper, universal pH paper, phenolphthalein, red cabbage extract are called by the common name .....
- Indicators are substances, which change their ..... according to the surrounding,
- State of matter of indicators can be .....
- In the lemon juice solution there is ..... acid.
- In the vinegar solution there is ..... acid.
- In the Celascon solution there is ..... acid.
- Acids used at home are e.g. .....
- Acids in the laboratory are e.g. .....
- How do we dilute acids with water? .....
- What is the first aid after acid burns? .....
- Acidity of solutions can be determined also by a physical quantity, scale .....
- Acidic solutions have the value of this scale ..... than 7.
- Arrange the acids used in the experiment according to the level of acidity – from the least to the most acidic .....

Conclusions

1. How to determine if an unknown solution in the beaker is acidic?

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2. Compare your observation with the assumption that you wrote down at the beginning of the worksheet (hypothesis).

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Figure 3: Student worksheet, page 2

(iii) Criteria for judging assessment data

Scientific literacy

To assess the development of *scientific literacy*, the teacher analysed the student self-assessment cards after the teaching of topic (Table 1 and Figure 4). Formative assessment using a self-assessment card was utilised in this activity. As Figure 4 shows, most of the students can answer the

questions individually (73%) and only a little percentage of students need significant help from the teacher to answer (10%).

Table 1: Example of a self-assessment card after learning the topic "Acids"

Topic: Acids	with significant help from teacher	with teacher's help	individually
1. I can name... ...three acids used at home, and ...three acids used in a laboratory			
2. I can explain... ...what indicators are			
3. I can describe... ...the first aid after an acid-spill			
4. I know the principle of... ...how to dilute acids with water			
5. I can write down... ...the chemical formulas of three acids			
6. I can determine... ...if an unknown solution is acid or not			

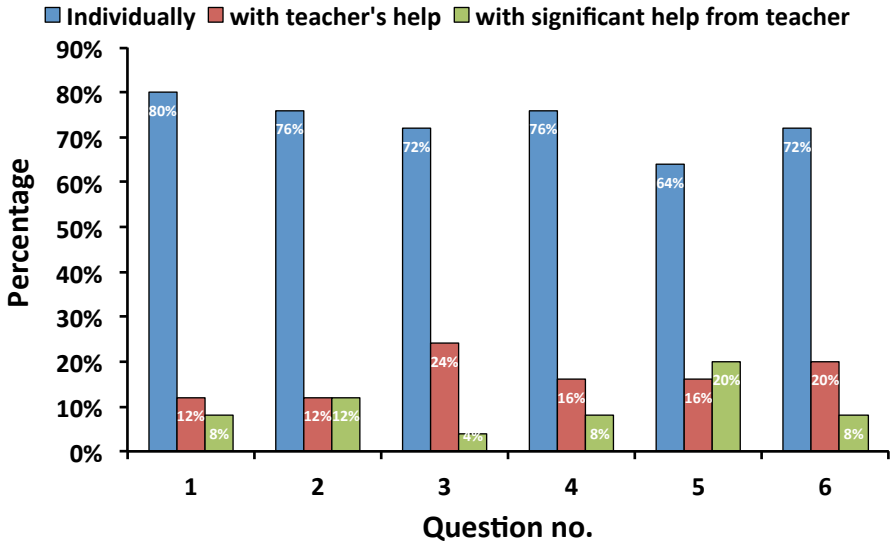


Figure 4: Analysis of student self-assessment cards

Developing hypotheses

Assessment of *developing hypotheses* was realised by analysis of students' answers to the following task in their worksheets: "Read the following work procedure and try to write down what will happen when you will be adding indicator into the acid." Students' answers were evaluated according to the accuracy of their hypotheses, on a scoring scale of correct, partly correct or wrong.

(iv) Evidence collected

Teacher opinion

Students reacted positively to this way of acquiring knowledge. Their interest could be seen already at the beginning, during the motivational questions. During the inquiry they cooperated effectively and evaluated the gained results. Non-traditional form of assessment was also an acknowledgment for them. Students liked the new way of teaching. They tried for thorough realisation of inquiry, to get the most accurate results. During the work they communicated, advised each other on how to

record their measuring and results and had a constructive dialogue with the teacher. They accurately filled in worksheets and considered time-management of the activity.

It was interesting to watch mutual communication of students during work, the way that they organised the group work, how they agreed, how they labelled the chemicals, how they formulated hypotheses, how they recorded the results, how they wrote data into the table and how they tried to formulate the conclusion. They worked really hard and thought about everything they were doing and they liked it.

From experience, I know that students often have problems with self-assessment of their performance aloud. The solution was the use of a student self-assessment card (Table 1) with this activity, which enabled students to evaluate the level of their knowledge of the certain topic. With the feedback I got an overview of understanding of the topic by individual students, which later enabled me to use individual approach to eliminate gaps in their knowledge.

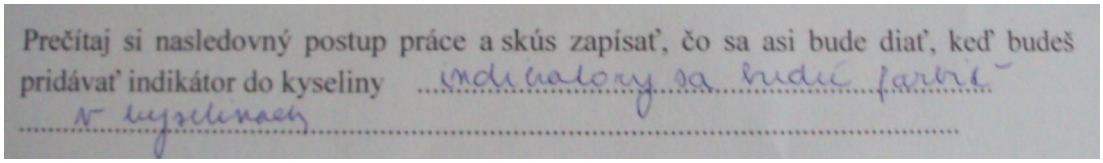
All the groups managed to fulfil the planned work procedure. I would recommend spending more time at the beginning to discuss the activity and its assessment method. I will continue using this form of assessment in the future, students liked it and as a teacher, I can get important information – what the students are good at and what they need to improve at.

Observer notes

Students worked very actively; they communicated and cooperated well. They kept on asking each other and teacher questions. They worked according to the instructions in worksheet. They tried to answer the given questions. Students did not have problems filling in the self-assessment card.

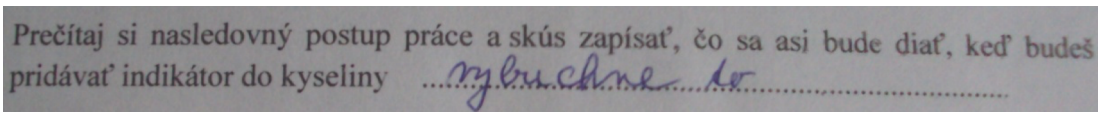
Sample student artefacts

Example 1: Example of a correct answer



Read the following procedure and try to write down what will happen when you pour indicator into acid:
Indicators will be coloured in acids.

Example 2: Example of an incorrect answer



Read the following procedure and try to write down what will happen when you pour indicator into acid:
It will explode.

(v) Use of assessment data

Every participant of the inquiry-based activity conducted reflection of their level of about topic Acids with self-assessment card. Evaluation of these cards provided me with feedback. The results showed that 73% of students were able to answer the questions individually and only 10% of them needed significant help from the teacher.

It was found out that writing the formulas of acids is a problem, which is confirmed by the results – only 64% of students can individually write down the formulas of three acids. The principle of acid

nomenclature is always challenging at the beginning and practicing is important. This result showed the need to add practicing lessons about nomenclature of acids into the next teaching.