4.5 Case study 5 (CS5 Poland)

Concept focus	Environmental impact of household chemicals
Inquiry skills	Planning investigations Forming coherent arguments
Scientific reasoning and literacy	Scientific reasoning (drawing conclusions) Scientific literacy (searching for information, presentation of scientific results)
Assessment methods	Classroom dialogue Teacher observation Student devised materials (final report) Presentations
Student group	**Grade:** upper second level **Age:** 16-17 years **Group composition:** mixed ability and gender; 10 students **Prior experience with inquiry:** No prior experience with inquiry

In this extracurricular, voluntary class, students' skills in *planning investigations*, *scientific literacy* and *forming coherent arguments* were assessed. The teacher took notes and recorded observations on students' *planning investigations* skills and assigned performance levels using a four-level rubric. To evaluate *scientific literacy*, students were asked to search for information on similar scientific investigations and to detail them in their presentations. Presentations were also used for assessment of *forming coherent arguments*; both skills were assessed at the group level.

(i) How was the learning sequence adapted?

The **Household versus natural environment** SAILS unit was implemented during extracurricular classes. The students were those who had chosen to study biology and chemistry or physic and mathematics in addition to their existing school subjects. The students formed two students groups.

Modifications of the original scenario

The introductory part of the first lesson of the scenario was omitted, as the students had discussed this issue earlier in the lesson. They had also attended hands-on laboratory classes during which they synthesised detergents and soap.

(ii) Which skills were to be assessed?

The activity was used in order to assess students' skills in *planning investigations* (including *developing hypotheses*), *scientific literacy* (presenting scientific results and searching for information) and *forming coherent arguments* (drawing conclusions).

(iii) Criteria for judging assessment data

The teacher used observation and rubric to assess students' skills. The teacher took notes and recorded observations in a grade book for extracurricular classes.

Planning investigations

The teacher used a four-level rubric for assessment of students' skill in *planning investigations* (Table 1), which was modified from the rubric in the unit.

Table 1: Assessment of planning investigations

Low	Acceptable	Good	Excellent
The student proposes a cleaning agent and a plant; specifies 1-2 steps of research.	The student proposes a variable, that he wants to investigate; specifies the basic steps of research.	The student formulates a hypothesis, specifies almost all research stages. The student suggests a method for data collection, and considers the standardisation of the procedure.	The student proposes a consistent and holistic (complete) research plan; predicts and solves problems that can happen and is critical about the designed procedure. The student suggests an innovative method for data collection, and considers the standardisation of the procedure.

Scientific literacy

To assess students' skills in both presentation of scientific data and searching for information, the teacher used the four-level rubrics proposed in the unit.

To assess the skill of presenting scientific data, the teacher analysed the presentations prepared by the groups (using MS PowerPoint) and their presentation skills when presenting in front of the class and the whole school. The teacher evaluated the work of whole group, because the students shared their work equally.

The assessment of skill in searching for information was based on analysis of similar investigations carried by scientists and the concepts connected with the influence of detergents on the environment. The teacher evaluated student documentation (report in the form of presentation) to assess this skill. The teacher evaluated this skill at the group level, because all the students took part in preparation of the presentation.

Forming coherent arguments

To assess students' ability in *forming coherent arguments* when drawing conclusions, the teacher analysed the group presentations using a four-level rubric (Table 2).

Table 2: Assessment of forming coherent arguments (drawing conclusions)

Low	Acceptable	Good	Excellent
The group draws nearly correct conclusions, but the reasoning is incorrect, e.g. students mix up cause and effect.	The group draws nearly correct conclusions; the reasoning is correct, but not detailed.	The group draws conclusions based on obtained results and identifies factors influencing the observed effects. They explain the conclusions using logical argumentation. They do not analyse potential sources of errors.	The group draws conclusions based on obtained results and identifies factors influencing the observed effects. They justify the conclusions using logical argumentation and present logical verification of the hypothesis. They analyse potential sources of errors.

(iv) Evidence collected

Sample student artefacts and teacher's opinion

Examples of students' work for the *planning investigations* phase are shown Figure 1 and Figure 2. Students were assessed individually for this phase, and the students in the first example were

assigned grades of excellent, good, acceptable and low (two students). The teacher observed that group 2 was a bit less creative than group 1. However, group 2 demonstrated better cooperation and division of duties. Students in this group were assigned grades of good, acceptable (two students) and low (two students).

1. Defining the research problem

How the detergents used in a household influence growth and appearance of plants? How cleaning agents influence the condition of plants, i.e. growth, speed of growth, colour of leaves and stalk?

2. Hypothesis formulating and substantiation

The higher the concentration of the detergent, the quicker growth of plants will be disturbed; leaves and stalk will wilt and colour changes will occur.

3. Selection of variables

- ***Independent – the value (that we change) influencing the value of a dependent variable:***
  - ***Concentration of solution, time, frequency of measurements***
- ***Dependent – the value that we want to calculate:***
  - ***Length, growth, colour of stalk and leaves, general condition of plants***
- ***Controlled – the values influencing a measurement result. They are fixed at the beginning of the measurement and kept remaining constant:***
  - ***Temperature, moisture, lighting, number of seeds in samples***

4. Elaboration of the variables control method

Defining the dependence between the variables. Elaboration of the effective method of variables control and processing.
Setting the experiment in class, on the windowsill, in the same conditions, in the same time; carrying out measurements in the same time (about 1.45 p.m.);
Into the Petri dishes we put cotton balls with cuckooflower seeds. We place toothpicks, on which we mark the height of plants. We measure the heights of all germinated plants with a setsquare by averaging the measurements (we reject the extremely small and high heights) and we mark the average height on a toothpick.
Two samples with cuckooflower (No. 0) are the control samples and they are watered with pure water only.
The samples with germinated cuckoo flower we divide into two groups (each group is numbered from 1 to 6): one group that we will water with the solution of "Ludwik" – the liquid for washing up dishes and the other group that we will water with the solution of "Wizir" – the liquid for washing clothes. The concentrations of the solutions were from 0,01 to 1000 ml of a detergent per 1 l of water. The solutions of lower and lower concentrations we prepared by diluting 50 ml solution of higher concentration in 450 ml of water.

5. Elaboration the method of raw data gathering

The plan for carrying out the experiment that enables us to gather data consistent with the defined variables and the methods of their processing.
The heights of plants measured by a setsquare for 4 successive days following germination we write in the table.
Then we put the data into the Microsoft Excel, we make the table and the diagram from which we try to read some dependences between detergent concentration and average height of plants in a given sample.

Figure 1: Example of planning investigations by group 1.

1. Defining the research problem

1. ***The influence of detergents on plants' development.***
2. ***The influence of a cleaning agent on plants' conditions: condition, growth, speed of growth, colour of leaves and stalk.***
3. ***How the detergents used in a household influence growth, speed of growth, colour of leaves and stalk?***

2. Hypothesis formulating and substantiation

1. ***The growth of plants is disturbed.***
2. ***The stalk and leaves become wilted and discoloured.***
3. ***The growth of plants is slowed down.***

3. Selection of variables

- ***Independent – the value (that we change) influencing the value of a dependent variable***
  - ***Concentration of solution,***
  - ***Time.***
- ***Dependent – the value that we want to calculate***
  - ***The growth of stalks,***
  - ***Colour,***
  - ***General condition.***
- ***Controlled – the values influencing a measurement result. They are fixed at the beginning of the measurement and kept remaining constant***
  - ***Lighting,***
  - ***Temperature,***
  - ***Moisture,***
  - ***Number of seeds.***

4. Elaboration of the variables control method

The setting of the experiment at the same place (windowsill), time and in the same conditions. The control of all factors that may cause an incorrect result and then incorrect conclusions.
The cotton balls with cuckooflower have been put into the Petri dishes. Toothpicks have been placed and the heights of the plants have been marked. The heights have been measured by using a setsquare.

5. Elaboration the method of raw data gathering

The rule of the experiment execution that permits to gathering the data consistent with the defined variables and methods of their processing.

Figure 2: Example of planning investigations by group 2.

Sample student artefacts – presentation of results

The teacher evaluated the groups' presentations using the proposed rubrics. For example, Group 2 achieved a grade of "good" for presentation and "acceptable" for searching for information (Figure 3).

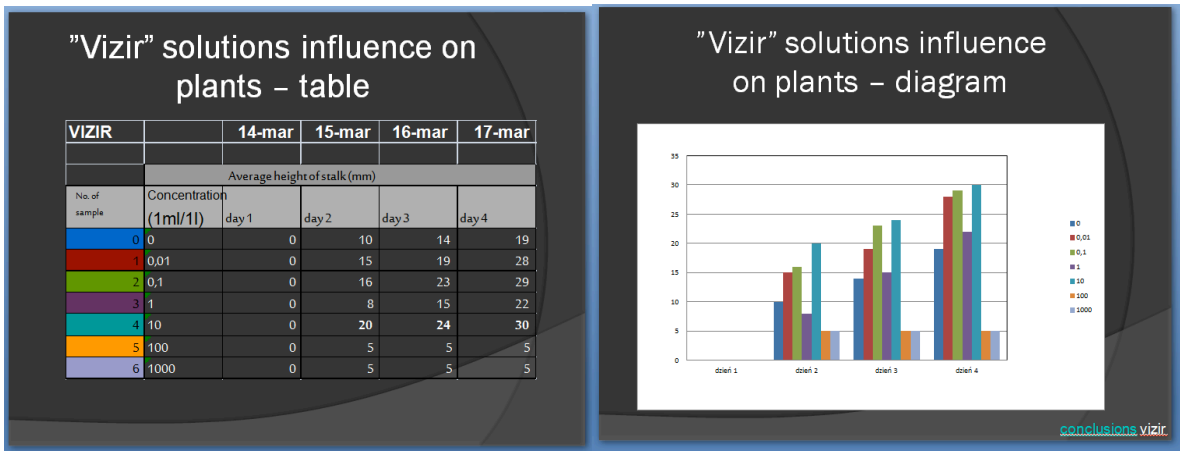

Figure 3: Presentation of results by group 2

Sample student artefacts – forming coherent arguments (drawing conclusions)

Figure 3 shows an example of the conclusions reached by group 2. The teacher evaluated the groups' skill in *forming coherent arguments* as "excellent."

Conclusions –influence of "Ludwik" on cuckoo flower

- ***Cuckooflower in samples I and II, watered with trace amount of detergent grows quicker than the cuckooflower in the sample 0 watered with water from water supply.***
  - ***Eutrophication phenomenon***
- ***In the samples III, IV, V, VI we observe increased disorder in the cuckoo flower, its stalks and leaves turn yellow a bit, the plants become wilted***
  - ***Over-fertilisation, toxic compounds***
- ***From sample III: the more detergent used, the more disorder observed in the plants.***

Conclusions – "Vizir" influence on cuckooflower

- ***In the samples I and II, watered with trace amount of the liquid, the plants grow better than in the sample 0, watered with water from water supply.***
  - ***Eutrophication phenomenon***
- ***In samples III, IV, V and VI the effects of harmful influence of the detergent are visible.***
  - ***Over-fertilization, toxic compounds***
- ***In spite of the differences between the liquid concentrations in samples V & VI, the development of cuckooflower proceeds in a similar way.***
  - ***At greater amounts of detergent, the difference between concentrations become meaningless***

- ***The hypothesis has been confirmed.***
- ***Typical cleaning agent used in household, such as "Ludwik" or "Vizir", have negative effects on natural environment.***
- ***Wastewater passing to the environment causes – like fertilizers – eutrophication (high content of phosphates). As a result, pollution of waters occurs, water organisms become ill and die.***
- ***Bacteria cannot decompose most of detergents used nowadays – the agents remain in the environment for a long time.***
- ***Surfactants present in detergents are toxic.***

Figure 4: Example of forming coherent arguments (drawing conclusions), by group 2.