4.1 Case study 1 (CS1 Slovakia)

Concept focus	Simple electric circuits Conductivity of everyday materials
Activities implemented	Activities A-C
Inquiry skills	Planning investigations
Scientific reasoning and literacy	Scientific literacy (searching for information; explaining lightning scientifically)
Assessment methods	Teacher observation Worksheets Student devised materials (mind maps) Other assessment items (post implementation test)
Student group	**Grade:** lower second level and upper second level **Age:** 14-16 years **Group composition:** mixed gender and ability; 10 different schools (10 teachers) with 12 classes participating with the total number of 215 students **Prior experience with inquiry:** None

This case study describes implementation by 10 teachers in 12 separate classes in Slovakia. In all cases, the skills assessed were *planning investigations* and students' ability to search for scientific information. The skills were assessed through evaluation of students' worksheets and teachers used rubrics to identify performance at four levels. The teachers provided written feedback for the students to review.

(i) How was the learning sequence adapted?

The learning sequence in the **Electricity** SAILS inquiry and assessment unit has been designed in three parts, namely Activity A: introduction to electricity, Activity B: simple electric circuit and Activity C: conductivity of different objects. Originally it was designed for lower second level; however we used it for students in the last year of lower second level as well at the first year of upper second level, with regard to the Slovak curriculum. As suggested in the original SAILS unit, students were asked to carry out different tasks: brainstorming on electricity (drawing a concept map), drawing a simple electric circuit in order to light up the bulb and planning and conducting an experiment on testing the conductivity of different materials, summarising the results and searching for information about conductivity of air and the human body. The learning sequence was followed as suggested. Although some teachers tried to carry out the lesson in one hour, most teachers decided to do it in two-hour sessions. There was a teacher who did the activity in three lessons.

(ii) Which skills were to be assessed?

The main elements of inquiry that this activity addressed were *planning investigations* and *searching for information.* Specifically, students were expected to use scientific language, draw a simple schematic drawing of experimental setup, plan a simple experiment, formulate a hypothesis, conduct a simple experiment, draw conclusions from the results of experiment, use different representations (drawings, tables, text descriptions), work in groups and search for information from different sources.

The skills were assessed with the help of rubrics. There were some rubrics that were designed to be filled in while observing students during their work (e.g. brainstorming activity and developing of the electricity concept map) that proved to be a very difficult task to do. Assessing the skills of *planning investigations* and *searching for information* were based on students written answers in the

worksheet, using rubrics that separated the students' answers into four performance levels – unacceptable/needs improvement/good/excellent (Table 1 and Table 2).

Table 1: Rubric for assessment of planning investigations

Assessed Skill	Unacceptable	Needs improvement	Good	Excellent
Planning investigation of conducting properties of different materials	The student... ... lists a limited number of objects made of 1-2 different kinds of materials but cannot write the plan at all or the investigation plan is incomplete	The student... ... lists a limited number of objects made of 1-4 different kinds of materials and the investigation plan is almost correct	The student... ... lists a limited number of objects made of over 4 different kinds of materials and the investigation plan is almost correct	The student... ... lists a limited number of objects made of over 4 different kinds of materials and the investigation plan is complete

Table 2: Rubric for assessment of searching for information

Assessed Skill	Unacceptable	Needs improvement	Good	Excellent
Searching for information	The student... ... finds information from 1-2 sources, but does not pay attention to the independence of the sources; summary is incorrect or incomplete and does not quote the source	The student... ... finds consistent information from 1-2 sources, but does not pay attention to the independence of the sources; summary is almost correct, but does not quote the source	The student... ... finds consistent information from at least two substantially different sources; summarises it in 3-4 almost correct sentences, quoting all or almost all sources of information	The student... ... finds consistent information from at least two substantially different sources; summaries it in 3-4 correct sentences, quoting all sources of information

(iii) Criteria for judging assessment data

Assessment of the brainstorming activity was omitted by most of the teachers. Assessment of drawing electric circuits, *planning investigations* and *searching for information* was based on rubrics, that separated the students' answers into four groups: unacceptable, needs improvement, good and excellent. This was clearly described in the activity. The teachers proposed the assessment category based on students' written reports. They mostly utilised formative assessment; teachers marked the assessed tasks with points and commented on wrong or incomplete answers. The reports with comments were returned to students for review. The teachers' opinion on this: once students are used to these kinds of inquiry activities and they know well what the teacher expects from them in order to fulfil all the tasks, summative assessment can be also carried out. However, some teachers used the end-of chapter test for summative assessment based on the complete knowledge about direct electric current.

(iv) Evidence collected

Teacher opinion

Teachers appreciated the activity a lot but need to train students for it, since they are not used to such kind of activity.

"I was inspired by this unit and assessment tools designed for this activity. It was quite new for students who are not used for this kind of activities and assessment. I think they need more training in this field."
"The proposed assessment tools evaluate students´ abilities in different aspects of inquiry well and it helped me to reveal problematic areas of students' abilities like to plan and express the investigation procedure, interpretation skills, on the other hand I was surprised by the activity and creativity of some students that have usually poor results."
"I was really amazed by this activity and so were the students and I would like to have more activities like this with detailed descriptions – materials for teachers and students available."

The teachers considered the assessment based on observing students during their brainstorming activity (assessing pre-knowledge, activity and creativity) and drawing a concept map rather problematic while the other based on the written reports collected after the activity was carried out without any major problems. As a result, teachers propose to leave the assessment of brainstorming and the concept map activity.

"I was expected to record students´ answers during the activity itself and this was rather confusing. The other activities were assessed based on the worksheet filled in by students so I could concentrate more deeply on it."
"Assessment of a group of students is rather problematic, since students reactions are spontaneous and sometimes the answer comes earlier from another student and not from the assessed one."
"Students did not write their predictions although I as a teacher ask them to do this. It may be caused by the fact they are not used to this kind of activity."
"The rubrics helped me a lot in assessment; however, I would not assess the brainstorming activity, since it is difficult to assess pre-knowledge and creativity".
"How to assess concept map? Is it a wrong answer if student first presents a wrong concept and then after the discussion with his peers or teacher he corrects his previous idea?"

Assessing drawings of working electric circuits:

"Assessment of schematic representation of the circuit – using schematic picture of elements or symbols for elements – assess the same thing – students already know the symbols for elements, they do not need to draw a picture of circuit."

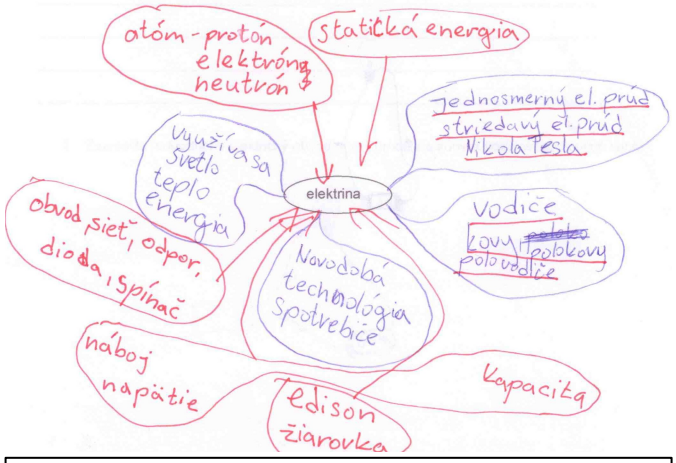
Assessing searching for information skills:

"It revealed problems with these skills since students were happy with one source, or they did not present the sources of information or they present them in a bad way."

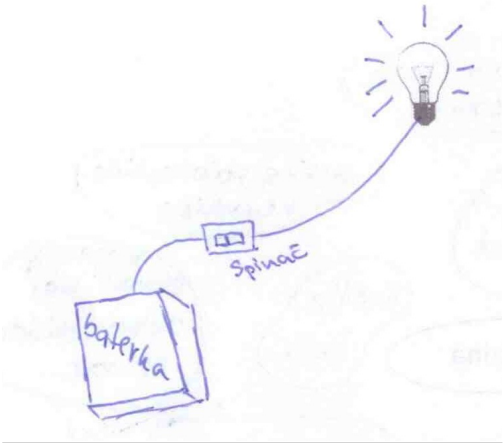
The teachers suggested dividing the activity clearly into three parts (within 2 or even 3 lessons). One of the teachers' proposals: first part to deal with the brainstorming and concept map development, second part to deal with investigation on conductivity of different materials. The end of the second part should involve discussion on conductivity of air and a short essay based on question: ***"Is electric current always dangerous to human beings?"*** and searching for information about lightning assigned as homework. The third part should involve discussion based on searched information about lightning, and communicating and presenting the essays.

Sample student artefacts

Shown in Figure 1-Figure 4 are examples of students' work and some example of assessment, while Figure 5 shows some images from the implementation.

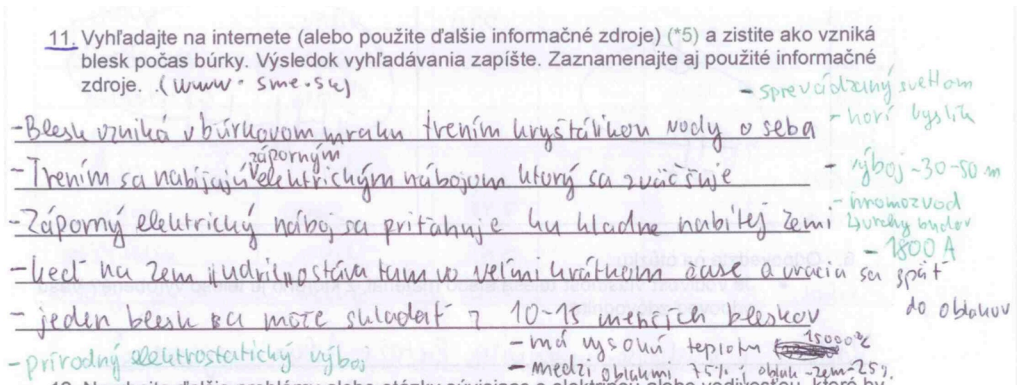


Example of the concept map around the term electricity, includes the following terms:
statics energy, direct current, alternating current, Nicola Tesla, conductors, metals, semiconductors, charge, voltage, capacity, Edison, bulb, circuit, resistance, diode, atom - protons, electrons, neutrons



Example of the wrong answer (circuit is not closed) to draw a simple electric circuit to light up the bulb
Assessment: ***unacceptable***

Figure 1: Example of a student mind map and a drawing of a simple circuit (incorrect).


11. Vyhľadajte na internete (alebo použite ďalšie informačné zdroje) (*5) a zistite ako vzniká blesk počas búrky. Výsledok vyhľadávania zapíšte. Zaznamenajte aj použité informačné zdroje. (www.sme.sk)

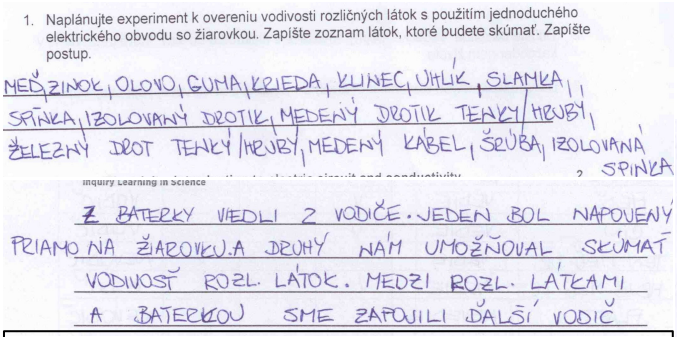
-Blesk vzniká v búrkovom mraku trením kryštálikov vody o seba
-Trením sa nabíjajú záporným elektrickým nábojom ktorý sa zväčšuje
-Záporný elektrický náboj sa priťahuje ku kladne nabitej zemi
-Ide na zem rýchlosťou tam aj veľmi krátkom čase a vracia sa späť
-jeden blesk sa môže skladať z 10-15 menších bleskov
-prírodný elektrostatický výboj

- sprevádzaný svetlom
- hrmí
- výboj ~30-50 m
- hromozvod
- 1800 A
do oblakov
- má vysokú teplotu 15000°C
- medzi oblakmi 75%, oblak-zem 25%

11. Search the Internet or other sources and find out how the lightning is formed during the thunderstorm. Write down 3-4 main steps, required to form a thunderstorm cloud and lightning. Quote the internet sources.
(www.sme.sk) Lightning is created in a thundercloud by friction between water crystals when crystals are charged. Negative electric charge of crystals is attracted to a positively charged Earth. It strikes to the Earth and goes back to the cloud. One lightning can be created from 10-15 smaller lightings. There is a high temperature (15000°C). Most lightings are between clouds (75%), 25/% are between Earth and cloud. There is a current of 1800A flowing in the lightning. It lights and oxygen is burning.

Assessment: ***needs improvement. There is only one source of information added. (Note however, many students´ answers did not contain this information)***

Figure 2: Example from the searching for information activity.

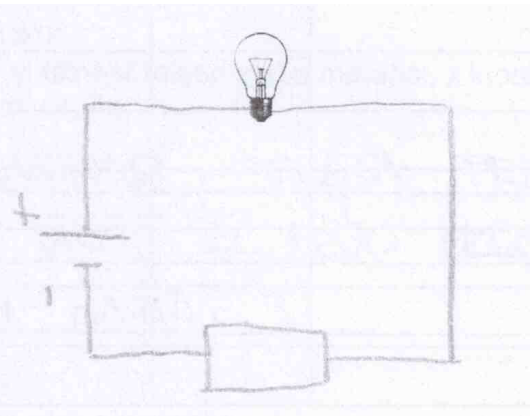

1. Naplánujte experiment k overeniu vodivosti rozličných látok s použitím jednoduchého elektrického obvodu so žiarovkou. Zapíšte zoznam látok, ktoré budete skúmať. Zapíšte postup.

MEĎ, ZINOK, OLOVO, GUMA, KRIEDA, KLINEC, UHLÍK, SLAMKA, SPÍNKA, IZOLOVANÝ DRÔTIK, MEDENÝ DRÔTIK TENKÝ/HRUBÝ, ŽELEZNÝ DRÔT TENKÝ/HRUBÝ, MEDENÝ KÁBEL, ŠRÚBA, IZOLOVANÁ SPÍNKA

Z BATÉRKY VIEDLI 2 VODIČE. JEDEN BOL NAPOJENÝ PRIAMO NA ŽIAROVKU. A DRUHÝ NÁM UMOŽŇOVAL SKÚMAŤ VODIVOSŤ ROZL. LÁTOK. MEDZI ROZL. LÁTKAMI A BATÉRKOU SME ZAPOJILI ĎALŠÍ VODIČ

1. Plan the experiment to check conductivity of different objects, using the electric circuit with a single electric bulb. Include the list of possible objects you could investigate in the classroom. Write down the plan below.
Copper, zinc, lead, rubber, chalk, nail, carbon, straw, paper clip, insulated wire, copper wire, thin/thick iron (copper) wire, screw, insulated paper clip

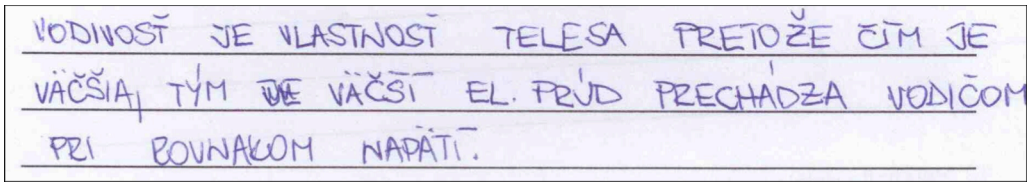
There were two wires coming from battery, one connected with a bulb and the other to the investigated material. The other ends of the bulb and the battery were connected.



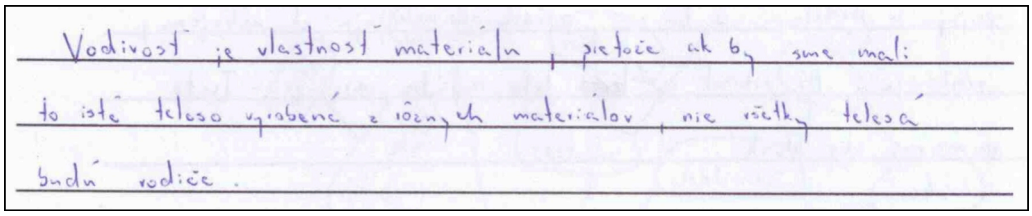
Draw the simplest working electric circuit enabling investigation of conducting properties of an object.
Assessment: ***excellent – the picture involves all the necessary components displayed in a schematic diagram.***

Figure 3: Two examples of planning investigations.

Student A


VODIVOSŤ JE VLASTNOSŤ TELESA PRETOŽE ČÍM JE VÄČŠIA, TÝM VIE VÄČŠÍ EL. PRÚD PRECHÁDZA VODIČOM PRI ROVNAKOM NAPÄTÍ.

Student B


Vodivosť je vlastnosť materiálu, pretože ak by sme mali to isté teleso vyrobené z rôznych materiálov, nie všetky telesá budú vodiče.

Write down your opinion, answering the question: Is conductivity an inherent property of an object, or a property of a material the object is made of? Explain your answer.
Student A: ***Conductivity is a property of material, because we can have the same object made of different materials and not all of them will be conductors.***
Student B: ***Conductivity is a property of an object, because if the conductivity is higher than there is higher current flowing at the same voltage.***

Figure 4: Demonstration of skill in scientific reasoning by two students.

Figure 5: Students and teacher participating in the unit implementation