4.4 Case study 4 (CS4 Slovakia)

Concept focus	Understanding light – improving scientific literacy
Activities implemented	Activities B-C, Activity G
Inquiry skills	Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (making reasoned decisions) Scientific literacy (application of scientific concepts)
Assessment methods	Classroom dialogue Self-assessment Worksheets
Student group	**Grade:** 3rd class of Gymnasium (upper second level) **Age:** 17-18 years **Group composition:** mixed gender; 28 students (divided into two groups, each group had 45 minutes for one lab-work lesson) **Prior experience with inquiry:** previous IBSE experiences with interactive demonstrations/discussion, guided discovery, guided inquiry (Establish Electricity and Sound lessons).

During this inquiry activity, the teacher observed group work and asked additional questions, guided students to the right approach, or provided a short explanation of physics background, if needed. The teacher tried to use formative assessment as much as possible, especially during group discussions and forming of conclusions, and provided feedback to the students about their progress. The teacher analysed students' worksheets after the lesson, with a focus on providing short comments and tips for improvements.

(i) How was the learning sequence adapted?

The **Light** SAILS inquiry and assessment unit was implemented in a single 45-minute lesson. Activities investigated were Activity B: What are sources of light, Activity C: Understanding shadows and Activity G: Exploring refraction, which were chosen based on school curricula and school timing for activities. The learning sequence followed the steps described in the unit with no significant modifications.

All activities were organised as *guided inquiry* with help of worksheets. Each student filled in their own worksheets during the 45-minute lab work session, which was carried out in cooperation with peers. After the lab work, worksheets were collected by the teacher and evaluated. During the next lesson, the results were discussed with the students, in particular possible improvements were noted. Students were permitted to improve their worksheets in accordance with the teacher's feedback. All worksheets are collected as part of a student portfolio, which students will use during their school leaving exams (Matura; high school exit examination). Topics with IBSE activities are included in the school final exam experiments list.

(ii) Which skills were to be assessed?

Inquiry skills to be assessed in this case study included *working collaboratively* and *forming coherent arguments*. In addition, students developed their *scientific reasoning* capabilities and their *scientific literacy*. Assessment was carried out both in class and after the inquiry activities. During inquiry activities, the teacher observed group work and provided small support, if necessary (for example, asked additional questions, guided students to the right approach, provided short explanation of physics background). Analysis of student worksheets took place after lab work, with a focus on student remarks for each activity, short comments and tips for improvements. For assessment of the worksheets, the suggested rubrics from the original unit can be used.

Working collaboratively

Groups of two or three students worked together with one equipment set, solving problems and fulfilling worksheets together. The teacher provided only a small amount of help in cases where students asked for advice. The teacher took note of individual students' involvement in problem solving, by observing the student activity. The teacher stimulated peer discussion by asking: "explain your opinion within your group and use arguments for it." The teacher observed teamwork and tried to improve collaboration within groups, especially in case of involvement of weak students.

Forming coherent arguments

For each drawing of light travel, shadows and refraction, students were introduced to *forming coherent arguments* and other questions discuss the relevance of arguments. In cases where the students were not sure they asked their teacher for help. Close to the end of their lab work, each group presented their own solution with argumentation.

Development of the skill of argumentation is still in progress; at the beginning students only said what they thought about the problem, but not why they thought this. During IBSE activities they are introduced to using argumentation for each of their decisions. The teacher can observe students' answers in their worksheets and write down comments for improvements.

Scientific reasoning

Step by step reasoning of scientific background is developed during these inquiry-based activities. Students focus on conceptual understanding of the problems encountered, not only on memorising knowledge. This approach supports the development of *scientific reasoning* very well, as reasoning is related to conceptual understanding of the problems. It can be measured by assessment of concept test questions.

Scientific literacy

When students are engaged in inquiry activities in school they are in the position of scientists at a school level. This role is a complex of different skills, knowledge and attitude.

(iii) Criteria for judging assessment data

Working collaboratively

In groups of two or three students (half class, up to 15 students) it's relatively easy to take care about the cooperation between students.

Forming coherent arguments

No empty space in worksheets where arguments are required.

Scientific reasoning

How well students can explain using their own words the reason of the topic.

Scientific literacy

We can observe the level of scientific approach within classroom, which means students' interest in the problem, focused discussions, active communication with their teacher and correct interpretation of problems.

The teacher tried to use formative assessment as much as possible during the lab works, especially during group discussions and forming of conclusions they made feedback to the students about their progress.

(iv) Evidence collected

Teacher opinion

Students enjoyed the activities a lot, because they can confirm their prior knowledge by experimentation and practical problem solving. They mentioned that better understanding of *scientific reasoning* and looking for arguments for making decisions were benefits of the inquiry approach. It's not easy, but they quickly recognised the benefits for understanding.

Practical experiences with a laser beam touching the water surface, shadow observation as well as light source observations help students to go deeper into the problem, not only memorise answers. The teacher evaluated worksheets and inquiry skills development only in qualitative way; feedback was provided on both in-lab activities and the submitted worksheets.

Observer notes

Some things that the students did not consider are:

- In case of refraction that also reflection is there
- Some of students didn't describe arguments, only made results
- In case of shadows mostly if they found one argument, it was enough
- Reflection from the walls is not considered at all, only direct rays to observer
- No arguments in case of perpendicular ray to the water surface.

In case of shadows not only point light source could be considered. We have it in curriculum also that penumbra would be discovered.

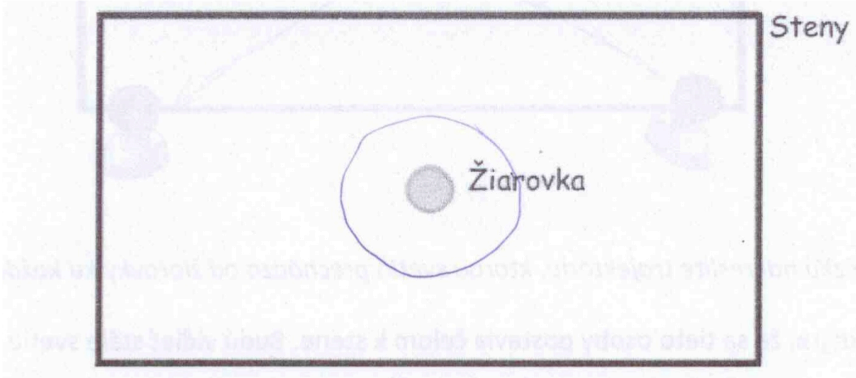
The students were familiar with an IBSE approach, as they had experiences from previous piloting through the Sound and Electricity Establish materials.

Sample student artefacts

Selected worksheets from the best students, practically oriented students and also weak students as representative sample are shown.

Activity B: How does light travel?

1. In the diagram below, the rectangle represents the walls (*Steny*) of the room and the circle represents the position of the bulb (*Žiarovka*). Where in the room would it be possible to detect light from the bulb? Mark this/these position(s) in the diagram.



2. Consider a person standing in the corner of the classroom.
Does light from the bulb travel as far as this person? How do you know?

2. V rohu triedy stojí osoba.

Šíri sa svetlo zo žiarovky až k osobe? Odkiaľ to viete?

áno, pretože osoba je nasvietená týmto svetlom, je ju vidno aj keď v triede nieje iný zdroj svetla.

Yes, because the person is illuminated by the light source even if no other light sources are there.

2. Consider a person standing in the corner of the classroom.
Does light from the bulb travel as far as this person? How do you know?

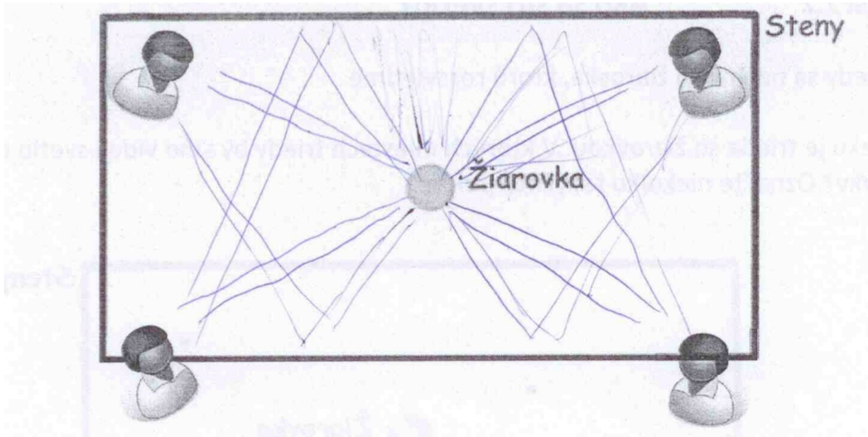
2. V rohu triedy stojí osoba.

Šíri sa svetlo zo žiarovky až k osobe? Odkiaľ to viete?

Áno, pretože osoba je v dostatočnej blízkosti (vzdialenosti) aj svetlo [illegible] nemá dosť

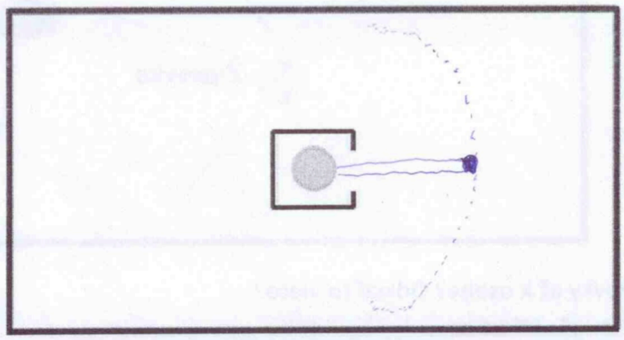
Yes, because the person is close enough to light source.

3. Now consider that four people arefacing the bulb.
Draw in the path that light takes from the bulb to each person.



5. A box with a small hole in the side is placed over the bulb.
Draw in the diagram where you would need to stand in order to see light from the bulb. Is there only one position? Explain.

5. Žiarovku umiestnime do krabice s malým otvorom.



Zakreslite do obrázka kde sa musíte postaviť, aby ste videli svetlo zo žiarovky.

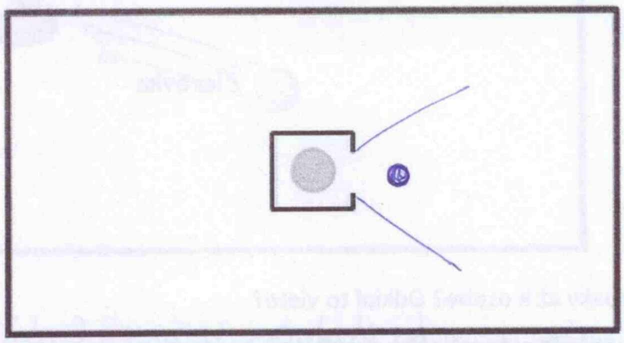
Bude to len jediné miesto? Vysvetlite.

Aby som videl žiarovku, musím stáť na konkrétnom mieste.

I could see the light source only if I'm staying in a specific place.

5. A box with a small hole in the side is placed over the bulb.
Draw in the diagram where you would need to stand in order to see light from the bulb. Is there only one position? Explain.

5. Žiarovku umiestnime do krabice s malým otvorom.



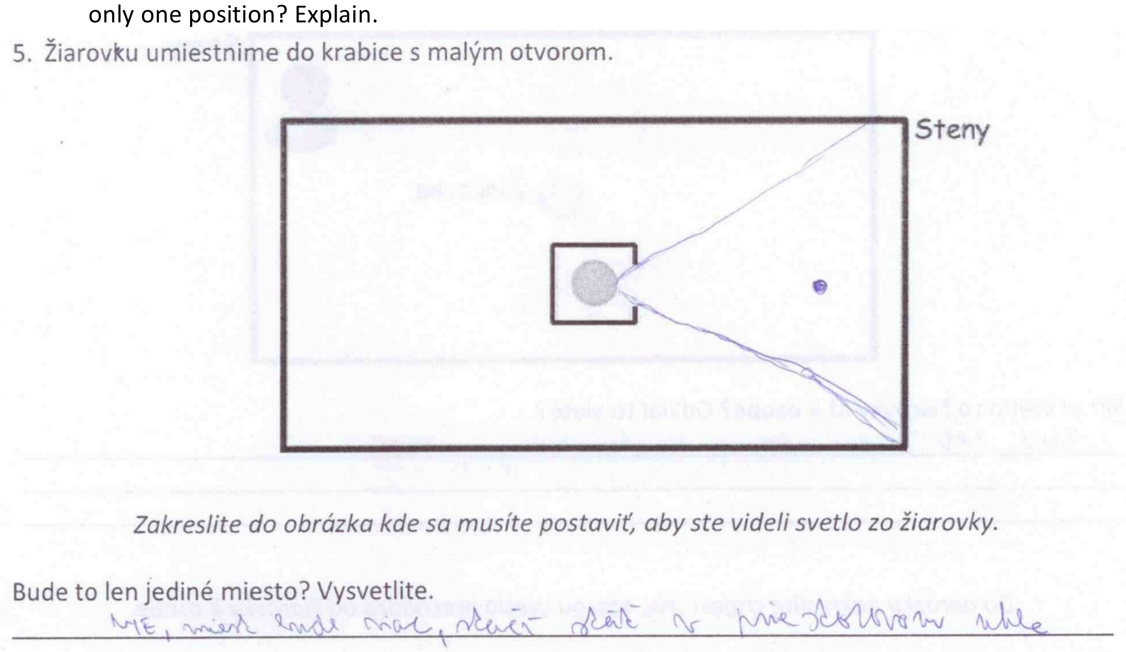
Zakreslite do obrázka kde sa musíte postaviť, aby ste videli svetlo zo žiarovky.

Bude to len jediné miesto? Vysvetlite.

je to uhol, v ktorom je svetlo, za uhlom svetlo nejde

There is only an angle where light is passing, outside that angle there is no light.

5. A box with a small hole in the side is placed over the bulb.
Draw in the diagram where you would need to stand in order to see light from the bulb. Is there only one position? Explain.

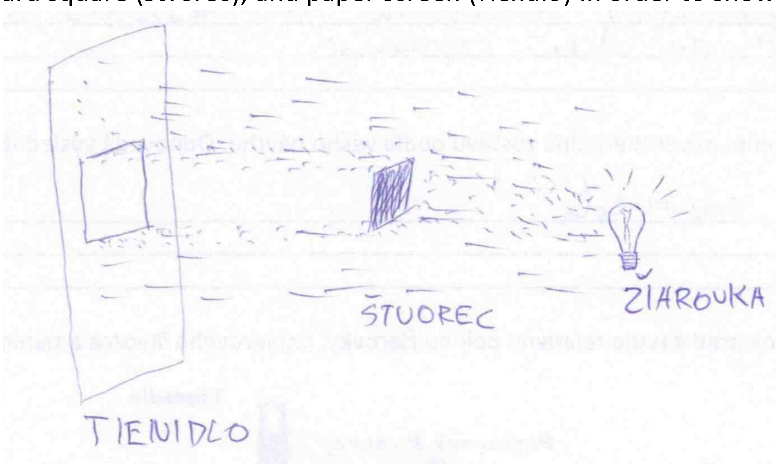


NO, a lot of suitable places are there, but you must stay in a specific space angle.

Activity C: Understanding shadows

Question 1

1. In the space below, draw a diagram of how you would set up a bulb (*Žiarovka*), cardboard square (*Štvorec*), and paper screen (*Tiendlo*) in order to show a shadow.

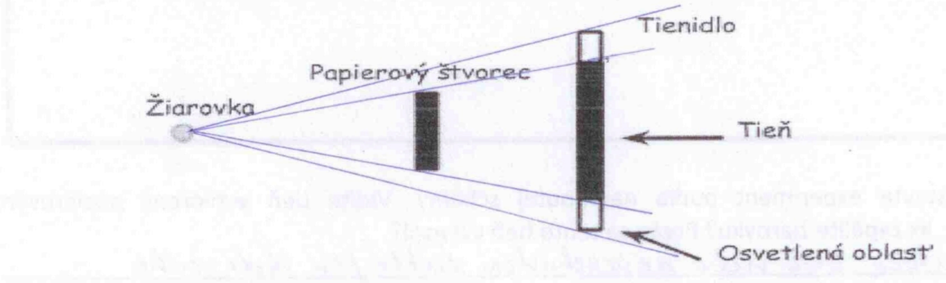


Question 7

7. The diagram below shows the relative positions of the bulb (*Žiarovka*), cardboard piece (*Papierový štvorec*), and paper screen (*Tiendlo)*. (*Tieň* = shadow; *Osvetlená oblasť* = bright region)

(i) Draw in the path that light travels from the bulb to the cardboard piece. Does this light reach the screen?

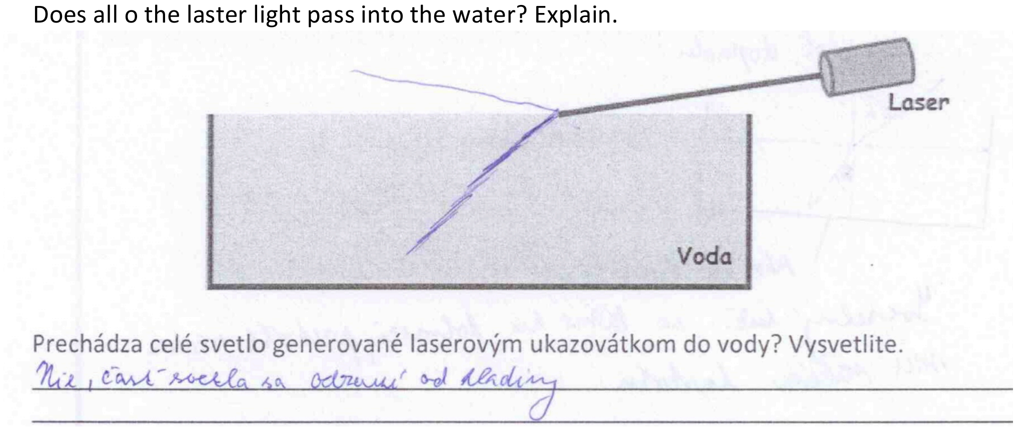
7. Obrázok predstavuje relatívnu polohu žiarovky, papierového štvorca a tienidla.



Activity G: Exploring refraction

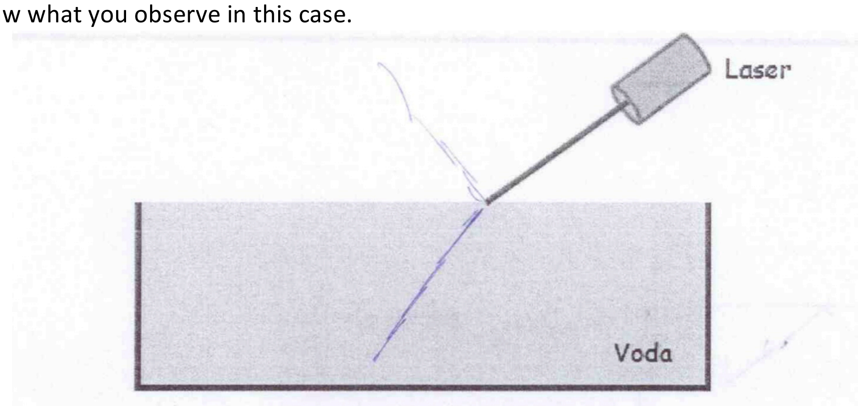
Questions 1-3

1. Consider that light from the laser pointer is directed towards the surface of the water, as in the diagram below. What happens to the path of light after it hits the surface of the water? Draw what you observe.
Does all o the laster light pass into the water? Explain.

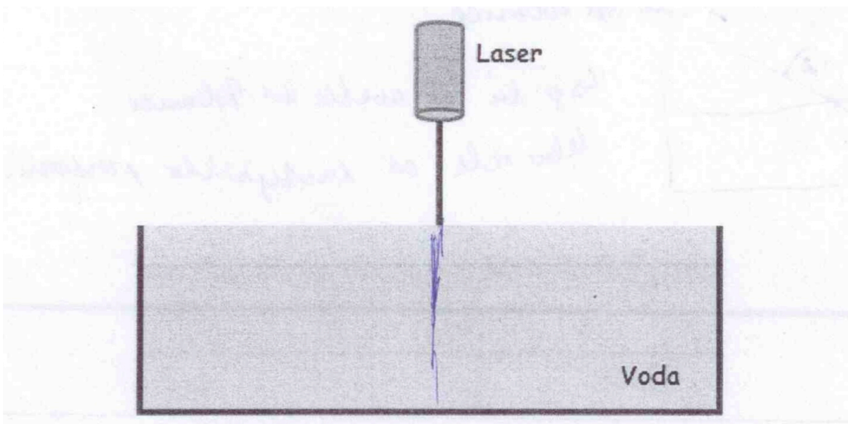


No, part of the light is reflected from the water surface

2. Suppose that you change the angle at which light from the laser hits the surface of the water. Draw what you observe in this case.



3. The laser is aimed at right angles to the surface of the water. Draw what you observe in this case.



(v) Use of assessment data

As these were third year students and had previous IBSE experiences, the teacher could have a look at students' portfolios and focus on improvement of *scientific literacy*. Students can do self-assessment about the level of selected inquiry skills.

Having received teacher feedback both during the lesson and through evaluation of worksheets, students were free to edit their worksheets to reflect what was learned from the feedback. This was done after the lab work, and marked by different pen colour.

(vi) Advice for teachers implementing the unit

- New teachers can take care of students' worksheets completing during group work, not after.
- Take care about the timing of activities steps. Make a time schedule before, and write it down into your own copy of the worksheets.
- Ensure that the discussion is related to developing skills in argumentation, not only memorising the facts.