

4.2 Case study 2 (CS2 Poland)

Concept focus	Investigating the living conditions of woodlice (or other insects)
Inquiry skills	Planning investigations Developing hypotheses Forming coherent arguments
Scientific reasoning and literacy	Scientific reasoning (data entry, drawing conclusions) Scientific literacy (data analysis and presentation of results)
Assessment methods	Classroom dialogue Teacher observation Student devised materials (investigation report) Other assessment items (in-class test)
Student group	Grade: lower second level (four classes; 27-31 student per class) Age: 13 years Group composition: mixed gender and ability Prior experience with inquiry: Students had no prior experience in IBSE; teachers had rarely used IBSE

In this case study, the students planned, carried out and analysed their investigations in groups, while the teacher observed their work process. Where students had difficulty obtaining woodlice, they instead used other insects or creatures such as earthworms. Skills assessed were *planning investigations*, carrying out an experiment, data analysis and presentation of results and drawing conclusions. The teacher modified the rubrics from the unit to reflect the Polish system of using a six-point assessment scale.

(i) How was the learning sequence adapted?

This case study details implementation of the **Woodlice** unit in four different classes. To accomplish the unit's tasks, three lessons (45 minutes each) were assigned in each class. At the beginning, the students were informed about the aim of the unit (learning to work according to scientific method with such elements as: *developing hypotheses*, defining variables, *planning investigations*, collecting data, formulating conclusions, identifying sources of error). During the first lesson, the students were asked to plan an investigation to determine the preferred living conditions of a woodlouse. The teacher did not show a woodlouse before introducing the topic. The teacher explained only (if students had doubts) what the animal looked like and where the students could find woodlice. A woodlouse is a fairly common animal, so it was readily available for the students. In the following lesson, the students were told to actually conduct their planned investigations, which were sometimes modified after teacher consultation. The last lesson was dedicated to summarising the work done and evaluating it. The students wrote their opinions and comments on the form of the lessons and their advantages.

Adaptations

The students planned, carried out and analysed the results of the experiments in their own groups only. During those activities, the teacher only observed the students. The teacher did not suggest any variables to be considered in the investigation, giving them an opportunity to work actively and use their imagination. In their attempts to plan the experiments, besides the basic parameters of the woodlice biology (food preferences, humidity, light intensity), the students also showed their interest in: avoidance of danger, way and speed of movement and other abilities (as swimming, ability to move on various surfaces of different inclinations) of the animal. The students showed their creativity when acquiring the animals for study, including the attempts to buy woodlice at pet shops and via the internet. In cases where students had difficulty obtaining real woodlice, students used other subjects instead, such as crickets, earwigs, beetles, centipedes, meal beetle larvae and

earthworms. In the draft unit, three lessons were required for complete implementation (the students used up much time using the experimental method).

(ii) Which skills were to be assessed?

The teacher identified opportunities for assessment of several inquiry skills, in particular *planning investigations*, carrying out an experiment, data analysis and presentation of results and drawing conclusions. The teacher used the proposed rubrics from the draft unit, and modified them to reflect the Polish system of using a six-point assessment scale.

(iii) Criteria for evaluating assessment data

Planning investigations

During the first lesson dealing with the characteristics of woodlouse biology, a rubric was used as a tool to evaluate the students' *planning investigations* abilities (Table 1). This rubric includes three levels of descriptive assessment of students' skills, to which a respective number of points was ascribed, which was then transformed to a resultant mark. The Polish 6-mark system was adapted (in descending order): 6 (*celujący* = excellent, not used in this case), 5 (*bardzo dobry* = very good), 4 (*dobry* = good), 3 (*dostateczny* = satisfactory), 2 (*dopuszczający* = mediocre) and 1 (*niedostateczny* = unsatisfactory/bad). Using the rubric, a maximum of 18 points could be attained in the area; mark levels were assigned as 0-5 (unsatisfactory), 6-9 (mediocre), 10-13 (satisfactory), 14-16 (good), 17-18 (very good).

Table 1: Rubric used to evaluate planning investigations

Assessed skill	2 points level	4 points level	6 points level
Asking questions	The student asks a series of questions, but s/he does not discern between the ones that are possible and impossible to answer by means of an investigation	The student, with help from others (students and the teacher), re-formulates questions, so as to make them possible to answer by means of an investigation	The student, without external help, re-formulates questions (own or others') after a discussion with other students and the teacher, so as to make them possible to answer by means of an investigation
Formulating hypotheses	The student formulates hypotheses that are impossible to be proven by means of a school experiment	The student formulates hypotheses that after the teacher's or other students' revision may be proven by means of a school experiment	The student independently formulates hypotheses that may be proven by means of a school experiment
Design of a scientific experiment	The student designs an experiment, but without precise description of its course and without taking its repeatability into account	The student designs a detailed experiment (or a series of them) using the teacher's advice or leading questions	The student independently designs a detailed experiment (or a series of them) selecting the conditions and identifying variables correctly and taking its repeatability into account

Carrying out the experiment

For this skill, assessment was based on the teacher’s observations. Students were assessed on their ability to use equipment and materials (using a rubric, see Table 2) and to execute an experiment.

Execution of a reaction was assessed by considering both data collection and documentation:

1. Data collection (maximum 2 points)
 - a. Compliance with safety rules and correct organisation of the working environment (1 point)
 - b. Experiment’s repeatability (1 point)
2. Documentation – data collection mode, e.g. table (maximum 2 points)
 - a. Correct construction of the table with description (1 point)
 - b. Correct filling in the table (1 point)

A maximum of 10 points could be attained in this area. Mark levels were assigned as 0-3 (unsatisfactory), 4-5 (mediocre), 6-7 (satisfactory), 8-9 (good) and 10 (very good).

Table 2: Rubric for assessment of student skill in use of equipment and materials

Assessed skill	2 points level	4 points level	6 points level
Equipment and materials preparation	The student can collect all materials necessary to conduct a basic experiment, without the change of the factors/variables	The student can collect all materials necessary to conduct a series of experiments, but with the teacher’s help	The student can collect himself/herself all materials necessary to conduct a series of experiments, grouping them respectively to enable measurements under the changing controlled parameters

Scientific literacy (data analysis and presentation of results)

To evaluate *scientific literacy*, students were assessed on their ability to interpret data graphically, identify bias or error and propose improvements (Table 3). A maximum of 18 points could be attained in this skill. Mark levels were assigned as 0-5 (unsatisfactory), 6-9 (mediocre), 10-13 (satisfactory), 14-16 (good), 17-18 (very good). Alternatively, it is possible to combine evaluation of skills scientific literacy and carrying out the experiment – for which the teacher used a five-level rubric (Table 4).

Table 3: Rubric for assessment of skills c) data analysis and presentation of results

Assessed skill	2 points level	4 points level	6 points level
Data analysis and presentation of results	The student interprets the data correctly (categorising the measured variables as lesser or greater), but is not able to create a proper graph based on the data	The student presents the data on a graph, but the graph lacks or has poorly developed elements such as axis titles, scale, legend, etc.	The student presents the data on an appropriate graph(s) including all necessary elements such as axis titles, scale, legend, etc. prepared correctly
	The student points out basic/selected sources of biased/incorrect results of the experiment	The student enumerates the main sources of biased/incorrect results of the experiment	The student analyses all main sources of biased/incorrect results of the experiment and indicates the ways to avoid such results in the future
	The student proposes the elements of the method serving to improve the experiment	The student proposes ways to improve the course of the entire experiment step by step	The student compares their results with other groups, discusses data interpretation and proposes methods to improve both their own and the other groups' experiments

Forming coherent arguments, scientific reasoning

To assess student skill in *forming coherent arguments*, judgements were based on questions posed to students. A maximum of 11 points could be attained in this section. Mark levels were assigned as 0-3 (unsatisfactory), 4-5 (mediocre), 6-7 (satisfactory), 8-9 (good) and 10-11 (very good).

First, an open question was posed, to assess students' ability to formulate conclusions:

1. What conclusions can you draw based on the investigation carried out?

Merits of the conclusion (0-2 points): 1 point – ok; 2 points – merits and language (formulation) of the conclusion – good.

At the end of the experiment, during the lesson the students, in groups, answered some test questions (Figure 1). The test is a kind of recapitulation, so it is useful, while also it is not time consuming.

Table 4: Rubric for assessment of skills b) and c)

Assessed skill	Unsatisfactory	Mediocre	Satisfactory	Good	Very good
1. Raw data collection, use of available tools and technology	The student records the results in a careless way, without paying attention to the measurements timing and units used. S/he is not able to construct a table to compare the results obtained. The student does not take care of the order at the workbench or of the safety rules.	The student records the results partially correctly, not always paying attention to the precision of the measurements. S/he is able to construct a table with the teacher's help. The student does not take much care of the order at the workbench and not always adheres to the safety rules.	The student attempts to record the results in a systematic way, but not always using proper units. S/he constructs a table with a little help from the teacher. The student takes generally good care of the order at the workbench and of the adherence to the safety rules.	The student records the results in a proper way, but not always using proper units. S/he constructs a table himself/herself. The student takes generally good care of the order at the workbench and adheres to the safety rules.	The student records the results in a systematic way, always using proper units and taking care of the measurements' precision. S/he makes good use of the available tools and technology. The student always takes good care of the order at the workbench and adheres to the safety rules.
Collected data processing	The student cannot process the results obtained.	The student processes the obtained results with the teacher's help. S/he does not acknowledge the estimated (im)precision of the measurements.	The student processes the obtained results with a little help of the teacher, without estimating the measurements' precision.	The student processes carefully the obtained results, estimating the precision with the teacher's help.	The student processes carefully the obtained results, taking care of their precision (e.g. calculating means) and estimating the precision.
3. Results presentation and errors estimation .	The student cannot present the results using proper graphic techniques.	The student attempts, with the teacher's help, to construct a graph illustrating the results.	The student presents the results in the form of a graph, but without proper description of axes, without error bars, etc.	The student presents the results in the form of a graph, but without error bars.	The student presents the results in the form of a graph, including error bars.

<p>Question I. Find all the correctly formulated conclusions that could be drawn based on the investigation (T for true, F for false) (0-5 points)</p> <ol style="list-style-type: none"> 1. Basic food of a woodlouse are decaying remains of plants and animals. T/F 2. Woodlice feed on fresh plants. T/F 3. Woodlice sometimes eat other woodlice. T/F 4. Woodlice are active during the daytime. T/F 5. Woodlice serve as a prey to many animals, e.g. lizards. T/F 		
<p>Question II. Indicate the right conclusion(s) from the investigation. <i>Underline the proper answer with its true part and choose its right premise. (0-4 points)</i></p>		
Woodlice avoid <i>sunny/moist</i> places	because	it may lead to their death by drying out
Woodlice live only in <i>dry/moist</i> environment		their chitinous armour is impermeable to (not penetrable by) water

Figure 1: End of experiment test questions

After the experiments, the teacher decided on one single final mark, being more or less a mean of the particular “area-marks”, because students would have too many marks originating from one single experiment. Furthermore, four different marks from four separate areas would be lower than one mean mark, which could discourage the students. The final marks, however, were lower than the students expected, which appeared from a conversation with the students.

(iii) Evidence collected

Teacher opinion

During the first lesson (dedicated to the woodlouse living habitat), the three-level rubric was used as a tool for assessment of the skill *planning investigations*. The descriptive evaluation levels were ascribed certain points that were afterwards transformed into a final mark. The students had seen the rubrics before the lessons and they knew what the teacher was going to assess.

During the last lesson dedicated to the woodlouse living conditions, all data obtained during the experiments was brought together. The heterogeneity of the experimental objects was discussed. The hypotheses concerning, first of all, the feeding preferences of woodlice (based on the experiments conducted as homework by one of the students) and other arthropods (millipedes) were analysed. Respective tables and graphs were prepared, but their low statistical significance (low number of objects investigated and experiment repetitions) was stressed. The errors occurring in the course of the experiments were assessed, and the positive and negative aspects of the lesson accomplished using active methods (biological experiment) were analysed.

One of the students from the fifth group carried out the experiment himself as homework. The student was not satisfied with the results of his group; he is very ambitious and devoted his extra time to present his own idea of the experiment. That was the reason why the student got a higher mark.

Conclusions

1. Evaluation using the IBSE methodology is difficult for both the teacher and students. It requires adjustment and adaptation to every new situation; individualisation seems necessary.
2. Evaluating all students in the group using the same scheme (Table 5) may be unfair to individual students. Not all students in one group were involved in group work. Some of them should have got lower marks. It would be better for the teacher to focus on a few students only, not on whole groups and classes.
3. The majority of students are fascinated by discovering the world using a scientific method.
4. IBSE methodology is extremely time-consuming and in the reality of the Polish school education system (necessity of going through an extensive curriculum within reduced number of hours,

considerable number of students – often more than 30 – per class, lack of the necessary equipment) its implementation in its entirety seems impossible. Only some elements of the IBSE methods may be put in practice; nevertheless, it should have a positive impact on the educational results. Up to the present time, the majority of students have had no experience with the scientific method in their school education.

5. In the case of a few students, certain symptoms of zoophobia could be observed that also needs to be taken into consideration when accomplishing the units’ tasks involving real living creatures. Nevertheless, even such students have found those activities attractive and interesting, trying to get involved as actively as possible.

Table 5: Results of assessment for all groups

Assessed skill Mark	a) Planning an Investigation	b) Carrying out an experiment	c) Data analysis	d) Drawing conclusions
Very good	2	3	2	7
Good	5	4	1	9
Satisfactory	7	0	3	2
Mediocre	9	8	8	2
Unsatisfactory	1	9	5	0
Mean	2 (mediocre)	2.3 (mediocre)	2.3 (mediocre)	4.1 (good)

Student artefacts (Group VI)

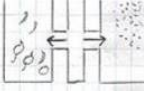

DOŚWIADCZENIE 1
materiały: 2 pomieszczenia z przegrodką, 5 stonóg
liście, wilgotna ziemia, piasek, kora, patyki, trawa

PRZEBIEG

1. Umieszczenie materiałów w wybudowanych przegrodkach.
2. Wypuszczenie stonóg do pokoju neutralnego (pustego).
3. Obserwowanie zachowania stonóg

WYNIKI
Po około 5 minutach stonogi rozszedły się w różnych kierunkach. Po chwili znalazły się w pokoju z trawą, ziemią i liśćmi.

WNIOSEK
Stonogi żyją w środowisku wilgotnym, oraz „zielonym”

EXPERIMENT 1

Materials: 2 chambers connected together with small room, 5 woodlice, leaves, wet grains, sand, bark, stick, grass

PROCEDURE

1. Put materials into chambers
2. Release the woodlice in empty (neutral) room
3. Observe animals' behaviour

RESULTS

After 5 minutes woodlice go in to different directions. Finally all woodlice were in room with wet grains, grass and leaves

CONCLUSION

Woodlice live in moist and 'green' environments.


DOŚWIADCZENIE 2
materiały: pokój wykonany z tektury, 5 stonóg
silne oświetlenie (szwalnia z lampki biurkowej)

PRZEBIEG

1. Wypuszczenie stonogi do pokoju
2. Uruchomienie oświetlenia

WYNIKI
Stonoga ucieka do zacienionego miejsca, krowa się, przed światłem.

WNIOSEK
Stonogi unikają światła, chowają się w cieniu



EXPERIMENT 2

Materials: room made of cardboard, 5 woodlice, strong lighting (desk lamp)

PROCEDURE

1. Release the woodlice
2. Turn on the light

RESULTS




Woodlice run away to the shady location

CONCLUSION

Woodlice escape from the light and hiding in the shadow

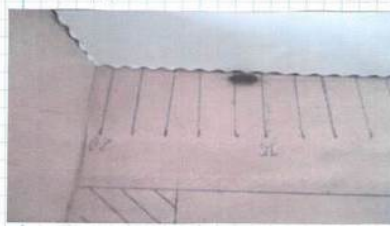
WYNIKI

rybnka	ser	banan	trawa	liście
+	+	+	+	+
			+	+
				+

WNIOSEK
Mimo tego, że słonogi rozbiegły się do różnych pokarmów można stwierdzić, że słonogi odróżniają się zjadłymi liśćmi lub trawą.

WYNIKI
Słonoga pokonuje dystans 5cm w ciągu około 2 sekund co daje jej prędkość 1,5m/min



WNIOSKI
Słonoga porusza się szybko jak na swój rozmiar. Może ona pokonać dystans 1,5m w przeciągu 1minuty.

RESULTS

ham	cheese	banana	grass	leaf
+	+	+	+	+
			+	+
				+

CONCLUSION

Despite the fact that woodlice went to various food, we can conclude that woodlice eat the grass or rotten leaves.

RESULTS

Woodlice passed the distance of 5 cm in about two seconds, giving 1.5 m/minute

CONCLUSIONS

Woodlice move fast for their size. Animals can travel the distance 1.5 meters during 1 minute.

Example of evaluation – Group VI

Equipment and materials preparation – 2 pts.

Investigation execution:

- Data collection - 2 pts.
- Documentation - 2 pts.

Marks: 6/10 points – satisfactory

The student can:

1. Present the data independently on an appropriate graph(s) with all necessary elements as axes titles, scale, legend, etc. prepared correctly (6 pts.)
2. Point out basic/selected sources of biased/incorrect results of the experiment (2 pts.) (too small sample, inadequately selected food (not occurring in nature), no repeatability of the experiment)
3. Propose the elements of the method serving to improve the experiment (2 pts.)

Marks: 10/18 points – satisfactory

Table 6: Woodlouse living conditions- experiment evaluation (1 “c” class)

Advantages of the experiment, i.e. what was good in the students’ opinion (in parentheses - number of repetitive answers given)	Disadvantages of the experiment (what was poor in the students’ opinion)	Proposals – how to deal with the disadvantages?
<ol style="list-style-type: none"> 1. Interesting experiments (5×) 2. Learning about nature 3. Cool/interesting lesson (11×) 4. Interesting topic 5. It was funny when girls were shouting and jumped on the chairs 6. Everyone in our group had his/her own view 7. Much emotion (4×)(some of it due to the escape of the millipedes) 8. An innovative form of a lesson/education – easier to learn (3×) 9. I liked the experiments because of “playing”/learning through play (2×) 10. We don’t hear unpronounceable words during the entire lesson 11. We did not learn during three lessons 12. You can let your imagination run – invent an experiment 13. Form[ul]ation of hypotheses (2×) 14. Discovering the secrets of the environment 15. Possibility to learn something on one’s own and not basing on dry facts. 16. Work in groups/cool cooperation (14×) 17. Skills of cooperation and tasks sharing 18. Curiosity and interest as a result of the experiments (5×) 19. Attempts to understand better other creatures/animals’ lives (2×) 20. Contact with nature 21. Making conjectures and formulating theories together with their verification and improvement (2×) 22. Unexpected, chance discoveries 23. Observation possibility 24. It was possible to show one’s creativity (3×) 25. Non-typical lesson 26. A bit relaxed lesson/atmosphere 27. More detailed instructions what we will do and how we will do it 28. It was not necessary to study very much 29. Integration during such lessons 30. Many people are kinaesthetic and we’ll learn more working in such groups 31. We learned much (3×) 32. I know [now] how to carry out experiments 33. I know [now] what a millipede looks like 34. You could relax during the lesson 35. You could talk during the lesson 36. I’d like to have more such lessons/I liked it very much(2×) 	<ol style="list-style-type: none"> 1. It was necessary to find a woodlouse oneself/investigation object hard to find (22×) 2. We could not carry out the experiment because of our group members/the “group” work is often in fact a single person’s work/not harmonised group (6×) 3. Wrongly composed groups 4. We did not understand all what we had to do (perhaps it was because we carried out an experiment ourselves for the first time/perhaps the Internet washed our brains and we did not understand anything) 5. Too little time (2×) 6. Low mark in spite of the preparation of all necessary materials (but for the worm) (3×) 7. All worms are loathsome (it was horrific, I trembled all the day and felt like something was creeping over me/I don’t like observing insects (if there were to be cats, I could find some) 8. Such lessons are difficult 9. You must make more effort than with the ordinary lesson 10. Indoor and not outdoor activities (2×) 11. Little involvement on the side of the class; we did not get into it. 	<ol style="list-style-type: none"> 1. The teacher could give us a woodlouse or use the results found on the Internet or suggest an object that is easier to find (e.g. earthworm, butterfly) 2. Improve the within-group cooperation 3. The groups should be composed randomly, not according to the students’ wish

Student evaluation

The students wrote down their observations and opinions individually, anonymously, on pieces of paper, and their notes were later analysed. There were both negative and positive opinions about the experiments (Table 6). The teacher was not surprised about negative opinions since there had been a few such opinions voiced. Furthermore, there is no one good method for everyone (without an exception); everyone has his/her own preferences.

Next time, teacher would make an introduction and modify the experiment, for example s/he may bring a copy of woodlice before the students start designing an experiment, discuss the ethical aspect of experiments on living animal organisms, and that may make the students more motivated.