4.2 Case study 2 (CS2 Poland)

Concept focus	Properties of plastics (density, thermal stability, combustion)
Activities implemented	Activities A-D
Inquiry skills	Planning investigations (including data collection) Working collaboratively (discussing with peers)
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Self-assessment Worksheets
Student group	**Grade:** 3rd grade (lower second level) **Age:** 16 years **Group composition:** 11 students (7 girls, 4 boys); realised as extracurricular class, for which participation was voluntary. **Prior experience with inquiry:** Students had no prior experience of inquiry. Very experienced teacher (>20 years in the profession), with good knowledge of IBSE methodology, but without experience in IBSE assessment.

The **Polymers** SAILS inquiry and assessment unit was implemented in full in this case study. The skills identified for assessment were *planning investigations*, including collecting scientific data, and *working collaboratively*. Formative assessment was used for each skill. The teacher developed two tools for use in evaluating skills in *working collaboratively* – an observation card to record participation and a four-level rubric to evaluate students' skill. Other assessment methods consisted of reviewing student worksheets and self-assessment questionnaires.

(i) How was the learning sequence adapted?

The **Polymers** SAILS unit was implemented in full during two lesson periods. The class began with a presentation to the students detailing the objective of the investigation and its general structure. At first the students discussed the topic of polymers – the questions suggested in the unit were used in the discussion: Is plastic useful? What properties make the widespread use of plastic possible? Do all kinds of plastic have the same properties? Do plastics change with time? Which plastic material properties would you like to explore in more detail? Do the materials made of plastic have negative properties? In order to facilitate the discussion for the students, the questions were displayed on a projector.

Before proceeding to discuss the above-mentioned issues, the students were asked to write down their answers on sheets of paper. The signed sheets were collected at the end of the discussion and used as a basis for the students' evaluation. All students attended the discussion; they sat around a large table, so that they could see each other. Relation between gender and activity of students in the discussion was not observed. The person moderating the discussion was the teacher, but he did not interfere with what the students were saying.

After the end of the discussion, the students were divided into five groups: four pairs and one group consisting of three students. The students created the groups themselves – three groups were single sex and two mixed. In the groups, students performed laboratory experiments and completed their worksheets. Each group had access to common laboratory reagents and equipment and the students were free to choose the reagents and equipment for the following experiments

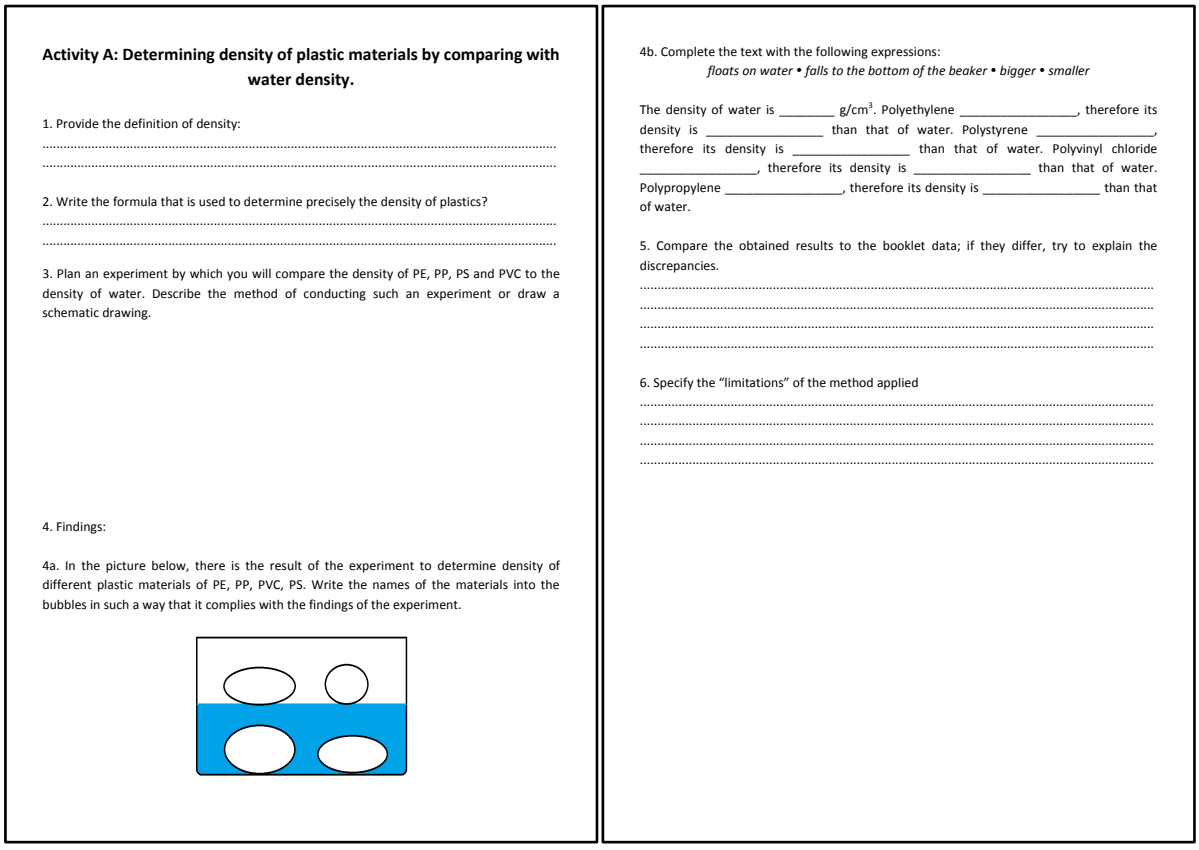
1. Determining the density of plastics by comparing it to the density of water
2. Flammability of plastics (without the Beilstein test)

3. Thermal stability of plastics
4. Examining the thermal conductivity of plastics
5. Electrical conductivity of plastics

Adaptations

The worksheet for Activity A was modified slightly (Figure 1) and for other activities the worksheets suggested in the original unit were used. The students did not manage to do Activity D: Electrical conductivity of plastics, due to the lack of time. The teacher decided not to perform the Beilstein test, due to the emission of HCl.

After carrying out all the exercises, all the groups met in order to discuss the results, using the same arrangement as at the beginning of the class. At the end, the students completed self-assessment questionnaires, in which questions concerning all parts of the class were included. In general it can be concluded that the investigation was attractive and interesting for students. No gender preference was noticed.



Activity A: Determining density of plastic materials by comparing with water density.

1. Provide the definition of density:
.....
.....

2. Write the formula that is used to determine precisely the density of plastics?
.....
.....

3. Plan an experiment by which you will compare the density of PE, PP, PS and PVC to the density of water. Describe the method of conducting such an experiment or draw a schematic drawing.

4. Findings:

4a. In the picture below, there is the result of the experiment to determine density of different plastic materials of PE, PP, PVC, PS. Write the names of the materials into the bubbles in such a way that it complies with the findings of the experiment.

4b. Complete the text with the following expressions:
floats on water • falls to the bottom of the beaker • bigger • smaller

The density of water is _____ g/cm^3. Polyethylene _____, therefore its density is _____ than that of water. Polystyrene _____, therefore its density is _____ than that of water. Polyvinyl chloride _____, therefore its density is _____ than that of water. Polypropylene _____, therefore its density is _____ than that of water.

5. Compare the obtained results to the booklet data; if they differ, try to explain the discrepancies.
.....
.....
.....
.....

6. Specify the "limitations" of the method applied
.....
.....
.....
.....

Figure 1: Worksheet for Activity A: Determination of density of plastic materials by comparing with water density

(ii) Which skills were to be assessed?

Three skills were selected for evaluation: *working collaboratively* (discussion with peers), *planning investigations* and data collection. Formative assessment was used in all cases. Data collected for assessment consisted of the student worksheets and self-assessment questionnaires.

(iii) Criteria for judging assessment data

Working collaboratively (discussing with peers)

The teacher decided to evaluate this skill, although it was not detailed in the original unit. The teacher developed two tools for use in evaluating this skill: an observation card to record participation (Table 1) and a 4-level rubric to evaluate students' skill (Table 2). The teacher utilised three sources of information for assessment of this skill:

1. Observation card: completed during teacher observation of students during the discussion
2. Student artefacts: collection and evaluation of sheets of paper on which the students wrote down their ideas for discussion
3. Self-assessment sheet: an overall assessment sheet completed by students at the end of the lesson (Table 3, the first three questions served for the assessment of that skill).

Table 1: Observation card for assessment of working collaboratively in CS2 Poland

Student name	Number of times s/he took part in the discussion	Did s/he do it herself/himself or was s/he asked to do it?	Factual correctness of statements	S/he provided interesting suggestions	Other notes (the ideas sheet)	Scoring

Table 2: Assessment of working collaboratively in CS2 Poland

1 point	2 points	3 points	4 points
The student rarely takes part in the discussion; The student does not listen to the other members of the group The student is not interested in the discussion (e.g. s/he does something else)	The student takes part in the discussion but only at the request of the person moderating the discussion The student's statements are not always factually correct The student listens to other students' statements	The student occasionally takes part in the discussion The student's suggestions are correct The student respects the opinions of other people, but s/he is not always able to notice incorrect (illogical) statements	The student often takes part in the discussion without the teacher's encouragement; The student provides suggestions that may be used by the group; The student provides correct substantive justifications The student can notice erroneous statements made by other discussion participants and s/he is able to correct them

Table 3: Questionnaire for self-assessment of working collaboratively (group work)

Specify how often each situation occurred when working in a group, using the scale shown below: 1: hardly ever 2: rarely 3: sometimes 4: often				
Assessment criteria	**1**	**2**	**3**	**4**
1. I took part in the discussion				
2. I listened carefully to what other students were saying				
3. I offered suggestions for the solution and other members of the group accepted them				
4. Other members of the group suggested the method for solving the problem and I agreed				
5. The ways to do the task were discussed together				
6. We developed the conclusions together				
7. I explained to the other members of the group how to formulate the conclusions				
8. Other members of the group explained to me how to formulate the conclusions				
9. We made the observations for the experiments together				
10. I suggested the observations to the experiments and my friends agreed				
11. I agreed to the suggestions of my friends				

Planning investigations

Assessment of the skill *planning investigations* was based on Activity A: Determination of density of plastics by comparing to the density of water. To assess the skill, the suggested tools included in the unit were used. Since other skills were assessed using a 4-level rubric, and the suggestion in the unit assumed a 3-level scale, the teacher added some suggestions for the fourth level (Table 4). Materials used for evaluation were the groups' worksheets and student self-assessment questionnaire (Table 3).

Table 4: Assessment of planning investigations in CS2 Poland

1 point	2 points	3 points	4 points
The student understands the task, but s/he does not know what the density is. S/he cannot plan the experiment independently.	The student knows what the density is; s/he can suggest how to assess the density of plastics in relation to water, but s/he cannot justify why a given scenario has been applied in the experiment.	The student is able to define density; s/he can suggest a procedure for determining the density of plastics in comparison to water; s/he is able to substantiate the course of the experiment.	The student is able to define density; s/he can suggest a procedure for determining the density of plastics in comparison to water; s/he is able to substantiate the course of the experiment. S/he is able to list the limitations of the method

Data collection

The assessment of the skill concerning data collection was based on Activity C: Thermal stability of plastics. The teacher evaluated group worksheets and student self-assessment questionnaires (Table 3). The methods for assessment of this skill were based on the tools provided in the unit. As before, a 4-level grading scale has been applied to assess students (Table 5).

Table 5: Assessment of data collection in CS2 Poland

1 point	2 points	3 points	4 points
Missing or incorrect data in the table	The data for four substances completed correctly in the table	The data for five substances completed correctly in the table An attempt to describe the structure of substance after taking it out of water	All data in the table completed correctly Described by more than one word, and all data that can be observed is completed

(iv) Evidence collected

Teacher opinion

Assessment of working collaboratively (discussing with peers)

The ability to take part in the discussion turned out to be very difficult for me to assess. While listening to what the students were saying, I found it difficult to take notes simultaneously. The students also behaved differently when they knew that they were assessed. Notes on sheets of paper cannot be the basis for the assessment of the ability to participate in the discussion, since some people do not need them to take an active part in it. It would have been easier to assess that ability if the students had conducted discussion in small groups, but in such case the teacher would be able to assess only one, selected group – s/he would not know what the others were doing.

In the self-assessment sheets only one female student indicated that she rarely took part in the discussion. The rest claimed that they spoke often or very often. Clearly, there was a great variance between what the students said and my own observations, most probably due to the fact that they completed the self-assessment sheets after the class, i.e. after the discussion in small groups. The discussion in pairs, in turn, I was not able to assess since, for safety reasons, I had to walk around the classroom and I could not observe the work of one pair only. The work positions of each group should be arranged so that the groups do not interfere with each other.

Students should know which elements would be assessed. The discussion, in my opinion, should guarantee the students an opportunity to present their conclusions, even if their statements are not always factually correct. However, if they know that this element is subject to assessment, they may be afraid of expressing their own opinions. It was the first class of such a type for the students, and thus I did not want to interfere with their work. I did not call the students up to the blackboard, as there were persons who willingly took part in the discussion. Definitely, it would be easier to assess the ability in a smaller group.

Assessment of planning investigations

It is possible to assess a group (two persons must get the same mark), especially if we deal with large number of groups. The worksheets are helpful when assessing the skill. What raises doubts is the degree to which the teachers should help the students. I tried not to interfere in the students' work, but the students came to the class voluntarily, so, in theory, these were those who are interested in chemistry. That is why they all coped with the task well. However, if a significant hint from the teacher is necessary, it needs to be taken into account when suggesting the mark. Such exercises make sense if students are not prepared for them and they plan an experiment during the class – if the topics discussed are new (which ensures students' interest), they are allowed to make mistakes. If such activities were carried out more frequently, it would be probably possible to require more from the students.

Assessment of data collection

The experiment for the assessment of data collection ability was suggested in the unit, but in my opinion it was inappropriate. The skill was assessed on the basis of worksheets completed by the students – proposed by the authors of the unit. Since students did not know that they were required to provide a broader description of substances – in the table they put only plus or minus signs (+/-), or they wrote YES/NO. The ability should be assessed on the basis of the experiment, which provides a lot of data, or the worksheet needs to be more precise. However, a very detailed worksheet may reduce the creativity of students.

Sample student artefacts

Working collaboratively (discussing with peers)

Examples of the student self-assessment of group work questionnaires (Table 3) are provided in Figure 2. In example b, both students in the group completed the same self-assessment questionnaire (O and M are student initials).

(a)

Ocena pracy w grupie		1	2	3	4
1	Zabierałem głos w dyskusji				✓
2	Słuchałem uważnie wypowiedzi kolegów				✓
3	Podałem propozycje rozwiązania i pozostali członkowie grupy je zaakceptowali				✓
4	Pozostali członkowie grupy zaproponowali sposób rozwiązania i ja się zgodziłem/-am				✓
5	Sposoby rozwiązania zadania były omawiane wspólnie				✓
6	Opracowaliśmy wnioski wspólnie				✓
7	Wytłumaczyłem pozostałym członkom grupy w jaki sposób sformułować wnioski		✓		
8	Pozostali członkowie grupy wyjaśnili mi jak sformułować wnioski	✓			
9	Obserwacje do doświadczeń prowadziliśmy w wspólnie				✓
10	Ja proponowałem obserwacje do doświadczeń a koledzy się zgadzali				✓
11	Zgadzałem się na propozycje kolegów				✓

(b)

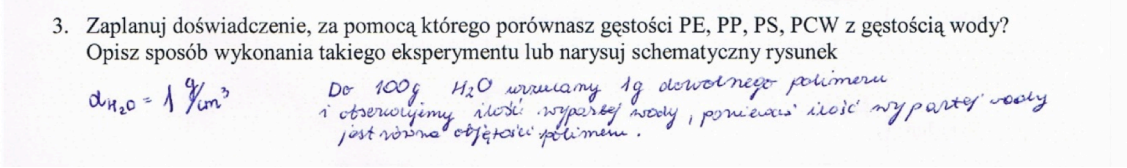
Ocena pracy w grupie		1	2	3	4
1	Zabierałem głos w dyskusji		O		M
2	Słuchałem uważnie wypowiedzi kolegów				O,M
3	Podałem propozycje rozwiązania i pozostali członkowie grupy je zaakceptowali				O,M
4	Pozostali członkowie grupy zaproponowali sposób rozwiązania i ja się zgodziłem/-am				O,M
5	Sposoby rozwiązania zadania były omawiane wspólnie				O,M
6	Opracowaliśmy wnioski wspólnie				O,M
7	Wytłumaczyłem pozostałym członkom grupy w jaki sposób sformułować wnioski				O,M
8	Pozostali członkowie grupy wyjaśnili mi jak sformułować wnioski				O,M
9	Obserwacje do doświadczeń prowadziliśmy w wspólnie				O,M
10	Ja proponowałem obserwacje do doświadczeń a koledzy się zgadzali			O,M	
11	Zgadzałem się na propozycje kolegów			O,M	

Figure 2: Examples of completed student self-assessment questionnaires

Planning investigations

For assessment of *planning investigations*, the teacher evaluated student responses to question 3 on the worksheet for activity A. Students are asked to "Plan an experiment by which you will compare the density of PE, PP, PS, PVC to the density of water. Describe the method of conducting such an experiment or draw a schematic drawing." Student's answers were translated directly, as detailed in the examples.

Example 1

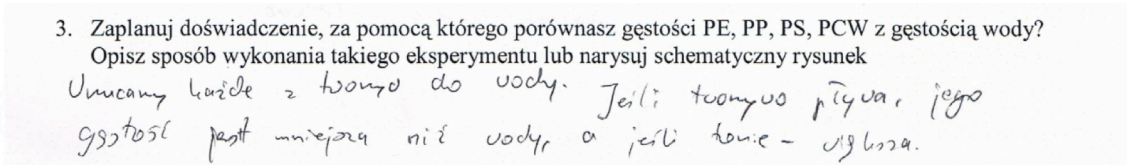

3. Zaplanuj doświadczenie, za pomocą którego porównasz gęstości PE, PP, PS, PCW z gęstością wody? Opisz sposób wykonania takiego eksperymentu lub narysuj schematyczny rysunek

$d_{H_2O} = 1\ g/cm^3$ Do 100g H_2O wrzucamy 1g dowolnego polimeru i obserwujemy ilość wyparłej wody, ponieważ ilość wyparłej wody jest równa objętości polimeru.

Translation: ***Into 100 g of water we put 1 g of polymer and watch amount of water that is pushed out. The volume of water that is pushed out is equal to volume of polymer.***

Teacher's comment: Students remembered to keep the mass of water and polymer constant, but the chosen method and lab equipment do not lead to correct answer. Students try to make the experiment in beaker, so the precision was too low to see difference between polymers' density.

Example 2

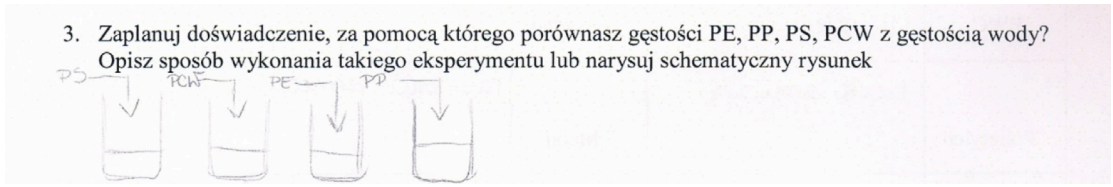

3. Zaplanuj doświadczenie, za pomocą którego porównasz gęstości PE, PP, PS, PCW z gęstością wody? Opisz sposób wykonania takiego eksperymentu lub narysuj schematyczny rysunek

Wrzucamy kazde z tworzyw do wody. Jeśli tworzywo pływa, jego gęstość jest mniejsza niż wody, a jeśli tonie - większa.

Translation: ***We put each polymer into water, if it float it's density is lower than water.***

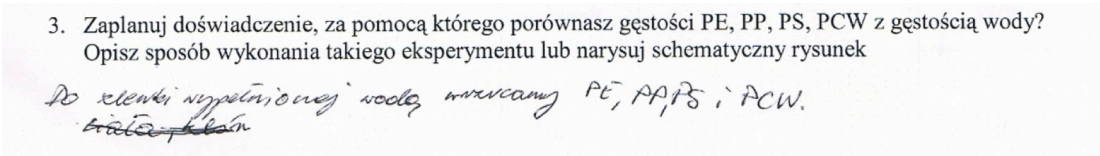
Teacher's comment: Students didn't decide what mass of polymer they will use, and what volume/mass of water.

Example 3



Teacher's comment: Students draw schema of the procedure, but without quantity. This approach is very typical in polish textbooks and at external exam questions.

Example 4


3. Zaplanuj doświadczenie, za pomocą którego porównasz gęstości PE, PP, PS, PCW z gęstością wody? Opisz sposób wykonania takiego eksperymentu lub narysuj schematyczny rysunek

Do zlewki wypełnionej wodą wrzucamy PE, PP, PS i PCW.

Translation: ***We put PE, PP, PS, PCV into beaker with water.***

Teacher's comment: Students didn't decide what mass of polymer they will use, and what volume/mass of water. It's not clear if they want to put all polymers together into water or separately.

Data collection

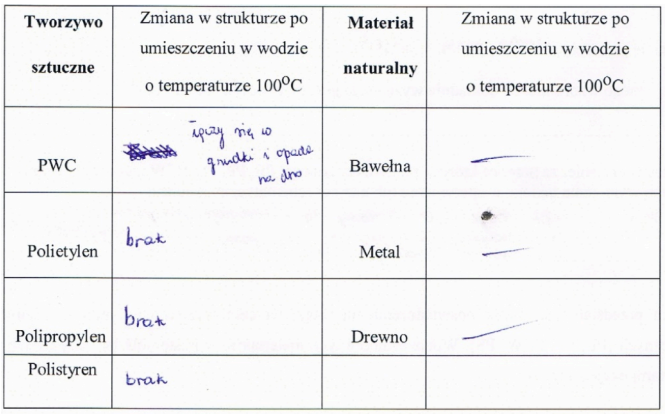
The teacher assessed this skill on the basis of completion of the findings table in the worksheet for Activity C (Table 6). However, as outlined previously, the teacher found that the tables were not sufficiently detailed and as a result students provided very short responses in their records.

Table 6: Findings table from activity C: thermal stability of plastics

Plastic materials	Structural change in boiling water	Natural materials	Structural change in boiling water
Polyvinyl chloride (PVC)		Cotton	
Polyethylene (PE)		Metal	
Polypropylene (PP)		Wood	
Polystyrene (PS)			

The teacher notes that "PVC used was in the form of powder, so students observe change in its appearance, maybe this it was misleading. Students had instruction with description of thermoplastics, but even though they didn't know what to measure or compare. In some cases they wrote not actual observation but what could happen if."

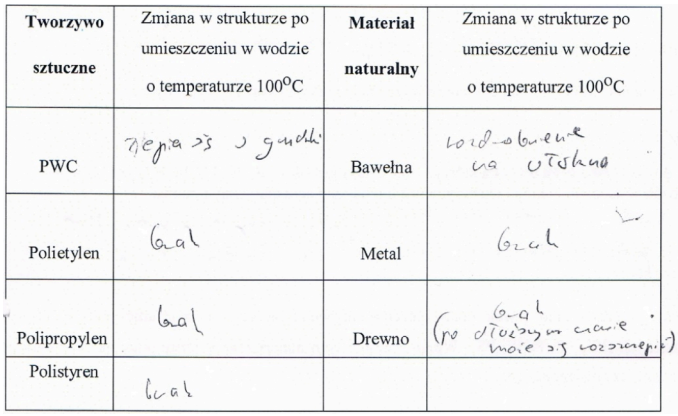
Example 1



Tworzywo sztuczne	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C	Materiał naturalny	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C
PWC	łączy się w grudki i opada na dno	Bawełna	—
Polietylen	brak	Metal	—
Polipropylen	brak	Drewno	—
Polistyren	brak		

Translation: ***PVC – connects into lumps and sink; all other – no effect.***

Example 2



Tworzywo sztuczne	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C	Materiał naturalny	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C
PWC	łączy się w grudki	Bawełna	rozpuszczenie na włókna
Polietylen	brak	Metal	brak
Polipropylen	brak	Drewno	brak (po dłuższym czasie może się rozpaść)
Polistyren	brak		

Translation: ***PVC – connects into foam and lumps; cotton – decomposes into fibres, wood – none (after long time it can split).***

Example 3

Tworzywo sztuczne	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C	**Materiał naturalny**	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C
PWC	łączy się w grudki	Bawełna	nie ma zmian
Polietylen	brak zmian	Metal	nie ma zmian
Polipropylen	~~brak zmian~~ staje się miększy	Drewno	nie ma zmian
Polistyren	brak zmian		

Translation: ***PVC – connects into lumps; PP – becomes soft, all other – no change***

Example 4

Tworzywo sztuczne	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C	**Materiał naturalny**	Zmiana w strukturze po umieszczeniu w wodzie o temperaturze 100°C
PWC	Topzy się małe grudki	Bawełna	—
Polietylen	—	Metal	—
Polipropylen	—	Drewno	—
Polistyren	—		

Translation: ***PVC – connects into small lumps***

(v) Use of assessment data

The **Polymers** inquiry and assessment unit was implemented as an extracurricular lesson and is a stand-alone lesson. The teacher discussed with students their results, but does not plan to continue the topic or work on the assessed skills. Further IBSE components will be implemented after an external exam in April. The teacher suggested that the IBSE skills are important, but because of the lack of their evaluation during external exam there is no point to focus on them before the exam.

(vi) Advice for teachers implementing the unit

The problem for Polish schools is the time – lower second level students have chemistry in 45-minute lessons. For this investigation two or three lessons are necessary, especially if we want to put emphasis on discussion.

Teachers should put emphasis on attention to safety during the combustion of polymers and students should perform this test in a fume hood.

The student self-assessment questionnaire was useful to assess the skill of *working collaboratively*, but not to assess *planning investigations* (including data collection). Theoretically, it should provide the means of evaluating individual students, but it did not work in practice. A better solution seems to be assessment of the entire group.