4.5 Case study 5 (CS5 Turkey)

Concept focus	Properties of plastics (density, thermal stability, combustion, electrical conductivity)
Activities implemented	Activities A-D
Inquiry skills	Developing hypotheses Planning investigations (designing experiments) Working collaboratively (discussing with peers)
Scientific reasoning and literacy	Scientific reasoning (recording data and observations)
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group	**Grade:** pre-service elementary teachers **Age:** 19-20 years **Group composition:** mixed ability and gender; 20 students **Prior experience with inquiry:** Very experienced with inquiry

This implementation describes trialling the **Polymers** SAILS inquiry and assessment unit with pre-service teachers. All activities were implemented, and the skills assessed were *developing hypotheses*, *planning investigations* and *working collaboratively*, as well as *scientific reasoning* capabilities. Skills were evaluated using completed worksheets and observation during classroom discussions. The discussions were also useful for the teacher to learn about students' ideas and thinking about certain subjects, as well as their skill in *working collaboratively*.

(i) How was the learning sequence adapted?

The **Polymers** SAILS unit was implemented in full during two double lesson periods (180 minutes in total). The teacher used the suggested worksheets from the original unit, but changed the order of implementation. This was to end the lesson with the combustion activity, thus allowing students to leave the class once the smoke was released.

The lesson started with an explanation about types of plastics, the meaning of symbols on plastic materials, and where they are used in daily life. This provided some background information for the students. A hand-out detailing properties of different plastics was shared with students (Figure 1, in Turkish)

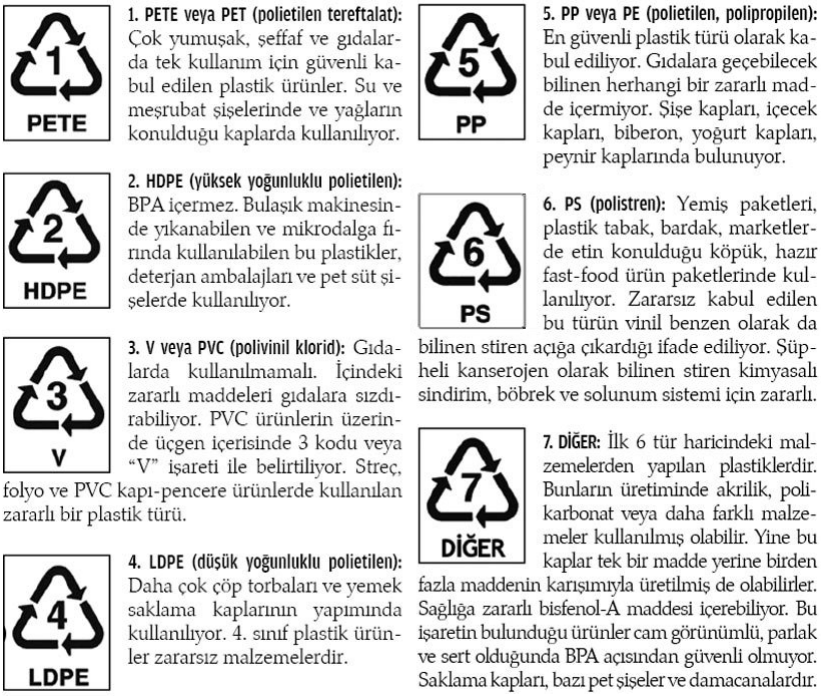

Figure 1: Symbols and information about different plastics (in Turkish)

After the initial explanations, students were given the first worksheet provided in the unit, which details Activity A: Determining density of plastic materials by comparing with water density. Students were also given materials needed in the activity. The teacher made a short explanation about the task in the worksheet and then let the students do the work. He was confident in students' ability to do the activity on their own because of their prior experience in doing inquiry activities.

In groups of four, students wrote their hypotheses about which material would float or sink in water. Student-selected groups were formed; some groups were mixed in terms of gender, while some were only females. The number of males was less than females, so some groups had to be only females. Most of the groups predicted that PVC would sink, PE may hang in the middle or sink, while PP and PS would float. They planned their experiments and carried them out (Figure 2). The planning phase was straightforward and easy for most students, as it only required putting materials in water. However, some groups provided important details in their plans, such as eliminating trapped air when putting plastic materials in the water for more accurate testing of floatability.

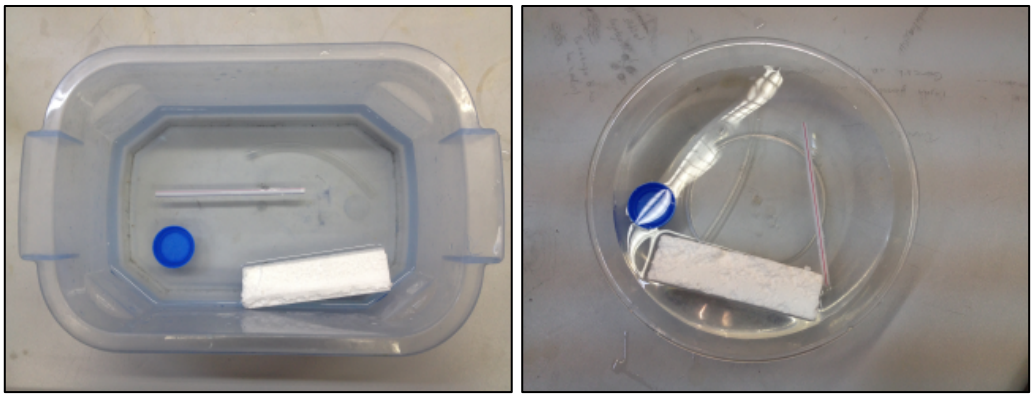

Figure 2: Examples of student investigations for activity A

The figure provided in the worksheet for recording observations did not conform to students' observations, so some groups drew their own figures about their observations, while others modified the figure in the worksheet (Figure 3).

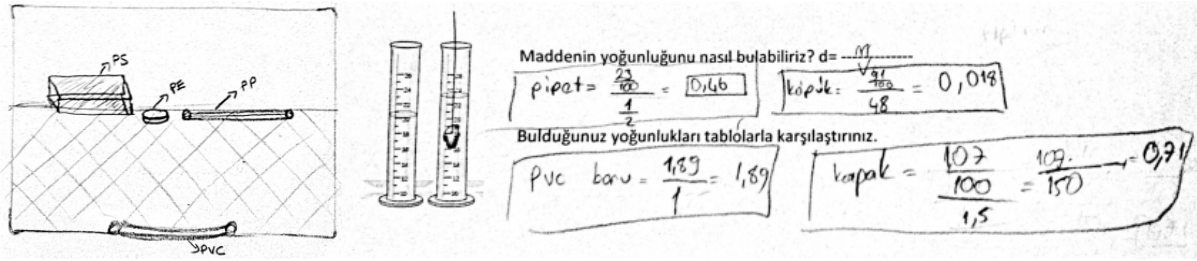

Figure 3: Examples of student worksheets

The floating experiment provided information about the densities of plastics relative to water. After students filled in the worksheet based on their observations, they went on to try to find the exact densities of each plastic (Figure 4). For this, they measured the weight and volume of each sample and made their calculations on the worksheet (Figure 3). This part of the activity was useful for developing and assessing students' skills of making accurate measurements, recording data, and performing accurate calculations.

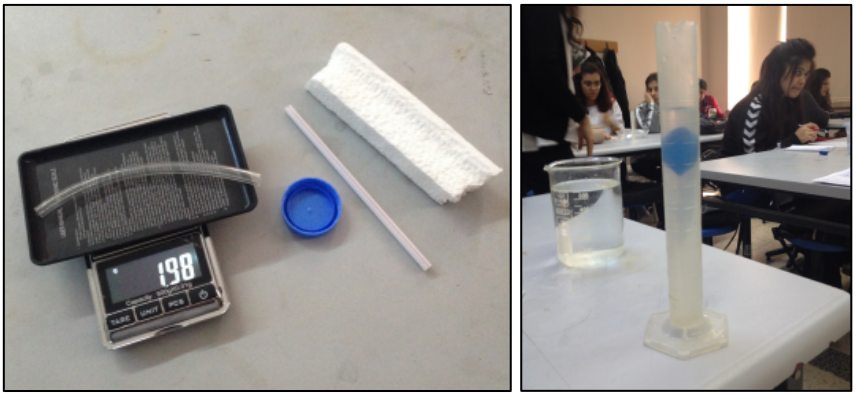

Figure 4: Further examples of student investigations for activity A

For the second investigation, Activity C: Thermal stability and thermal conductivity of plastic materials was introduced. The teacher passed out worksheets and gave a brief explanation about the task. The teacher decided to put only plastic materials in the boiling water and not try the cotton, metal and wood, since the focus of the activity was plastics. This part of the activity proved challenging because of the difficulties in observing the changes in plastics at 100 °C (Figure 5). Some plastic materials seemed a bit softer and more flexible in boiling water, but as soon as they were taken out, they returned to their original state very quickly. Students wrote their observations on the table provided in the worksheet. There were disagreements about some observations among groups, but most of them agreed that whatever change happened, it was little.

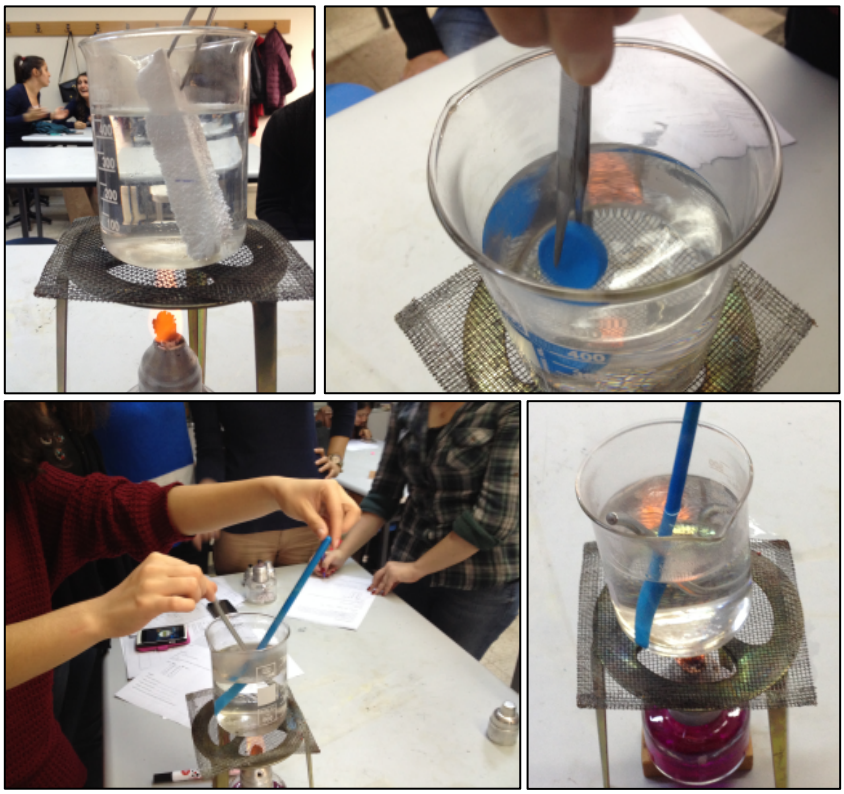

Figure 5: Examples of student investigations for activity C

In the second part of the activity, students placed a metal rod and a plastic rod in boiling water and recorded their observations about the heat conductivity of each one in one minute intervals (Figure 5). The worksheet asked for a hypothesis on the heat conductivity of metal and plastic. Students thought, this activity did not really warrant a hypothesis, since they knew what was going to happen. The teacher thought that asking students write a hypothesis for this activity was unnecessary, but they did this anyway.

A similar situation existed for the third activity (Figure 6, Activity D: Electrical conductivity of plastic materials). Students were asked to write a hypothesis about electrical conductivity of plastics, as well as cotton, metal and wood. Students thought that they already knew that only metal conducted electricity among the materials listed. So the hypothesis they formed did not provide a prediction about an unknown phenomenon. The second part of the activity was about static electricity. The hypothesis, procedure, and findings sections in the worksheet were very familiar for the students, since they did similar activities previously in as early as middle school. The teacher thought that this part of the activity could be turned into a more challenging inquiry activity and in its current form it was too simple.

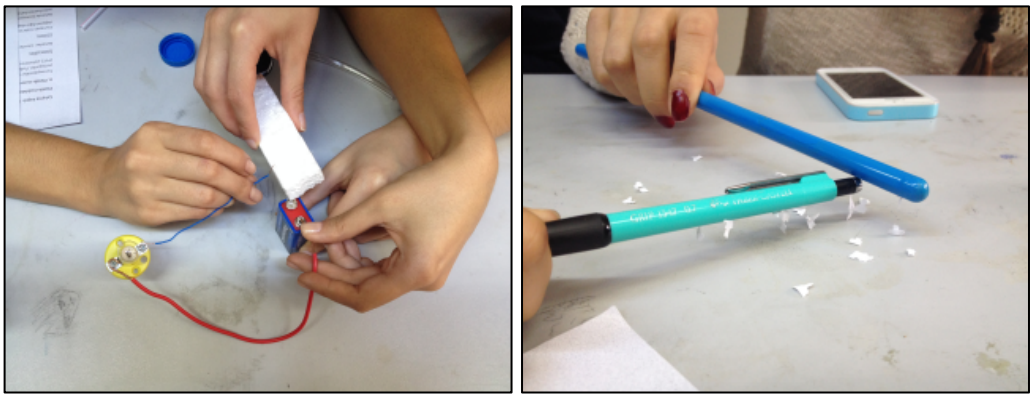

Figure 6: Examples of student investigations for activity D

The final part of the unit (Activity B: Combustion of plastic materials) was conducted by the teacher as the students observed (Figure 7). The reason was lack of enough burners for each group and safety about the amount of released gas. Teacher asked students about their predictions on what would happen when the plastics burned. They all thought that all the plastic samples would burn, but could not tell much about the characteristic of each burn.

Figure 7: Examples of teacher demonstration for activity B

After burning each plastic sample, students' observations were recorded. Only plastic cap (PE) showed some green colour in the flame in a brief moment, but the students could not be sure. Students enjoyed the activity, especially when they didn't know what would happen at the end. If they knew the results or if the results were too simple to guess, it was less interesting for them.

(ii) Which skills were to be assessed?

This implementation focuses on assessment of *developing hypotheses, planning investigations* and *scientific reasoning* (recording and using data, observations), which were evaluated using completed worksheets and observation during classroom discussions. The discussions were also useful for the teacher to learn about students' ideas and thinking about certain subjects (*scientific literacy*), as well as their skill in *working collaboratively* (debating with peers).

The teacher did not use the self-assessment tools for evaluation of *working collaboratively*, because he thought that most of the tasks were too simple for a complex group interaction and the self-evaluation tool was unnecessary. He also didn't use the teacher evaluation tool for students' group work, because he felt that it is easier and less time consuming to just observe students while they were working in groups and collect data from observation. He did notice some students not participating as they should and warned them verbally. In groups where there were males and females, usually boys took charge in more technical work, such as setting up the experiment,

modifying materials to fit their purpose, solving technical problems, etc. Girls usually took charge in tasks such as recording data, keeping time, assisting boys. However, in terms of expressing their opinions, there wasn't much difference.

The main concern of the teacher in terms of asking students to do a self-assessment was that they did not see a value in it because of the simplicity of most of the tasks. He used the provided rubrics for cognitive learning, but he modified them.

(iii) Criteria for judging assessment data

The teacher used the following criteria for making judgements about assessment data (Table 1). The assessment data came from worksheets and observations. In fact, it is quite difficult to use a rubric during the class. The teacher is busy with talking to students, listening to their comments, asking questions, discussing experiment setups etc. there is no time to utilise rubrics during the class time. The rubric is more useful after the class when evaluating students' reports or worksheets.

Table 1: Rubric for assessment of inquiry skills in CS5 Turkey

Inquiry skill	Poor	Needs improvement	Good
Developing hypotheses	The hypothesis is not testable or does not include variables	The hypothesis is testable but too general	The hypothesis is testable, contains sufficient detail, variables are evident
Planning investigations (designing experiments)	The suggested procedures are not clear, required materials are not specified clearly	The suggested procedures are clear but lack some details	The suggested procedures are clear and include details about how to make accurate measurements
Recording observations and data	The observations and data are not recorded or recorded in an unclear, untimely, and untidy way	The observations and data are recorded timely with some unclear statements	The observations and data are recorded timely and clearly
Working collaboratively (discussing with peers)	Does not participate in discussions does not express opinions or does not listen to others' opinions	Express opinions in a timid way, participate in discussions occasionally	Participate in discussions, listen to others, express opinions clearly and respect others

Another difficulty with rubrics is using them for individual students. Since most of the work is done in groups and evidence is collected in the form of group work, using rubrics for individual assessment is a challenge. There were students in each category, but not too many in the "poor" category.

(iv) Evidence collected

Teacher opinion

Teacher thought that somewhat more complex inquiry activities with less predictable results may help bring out students' skills and knowledge better as they would struggle a bit more to solve problems or to make decisions. When the tasks are simple or familiar to students, less information can be collected about their inquiry skills.

Students' performed quite well in this unit. They used inquiry skills such as *developing hypotheses*, *planning investigations*, *scientific reasoning* (recording observations and data), and *working collaboratively* (discussing with peers).

Discussing with peers was assessed by the quality of comments that students made and the number of different opinions and counter opinions expressed. When students disagreed on an issue and they expressed their reasons, this was an indication of competence in discussion with peers. For example, in some groups students were discussing whether they should consider PP plastic as swimming or hanging in the water. They expressed their opinions while others listened and then others offered their counter opinion. This observation was the evidence used for assessing "discussing with peers" ability. Lack of expressing opinions or counter opinions or not valuing others' opinions would mean this ability needs improvement.

For the other abilities, such as *developing hypotheses*, *planning investigations*, and recording data, students' written work on worksheets were used as evidence for assessment.

Sample student artefacts

One example of a satisfactory achievement was the detail one group provided about the procedure they designed for testing floatability of plastics. They wrote the importance of removing trapped air from the plastic materials, as they may interfere with whether the material would float or sink.

One example of a misconception was that some students thought that they had to sink an irregular shaped plastic all the way down to bottom of the graduated cylinder to measure the displaced water accurately. The teacher did a small experiment with those students to show that once the material was under the water, the water level did not change as the material was pushed down to the bottom. Initially students predicted that the water level would continue to rise as the material was pushed further down toward the bottom.