4.1 Case study 1 (CS1 Hungary)

Concept focus	Application of theoretical knowledge in a practical task
Inquiry skills	Planning investigations (implementing experiment, collection of data) Developing hypotheses (developing research questions)
Scientific reasoning and literacy	Scientific reasoning (drawing conclusions, critiquing experimental design)
Assessment methods	Classroom dialogue Teacher observation Student devised materials (experimental plan)
Student group	**Grade:** upper second level **Age:** 15-16 years **Group composition:** mixed ability and gender, groups of 3-4 **Prior experience with inquiry:** some prior experience

The main inquiry skill assessed in this case study was *planning investigations,* including looking at students' skill in carrying out an investigation. D*eveloping hypotheses* and *scientific reasoning*, evidenced through drawing conclusions and critiquing experimental design, were also assessed. Assessment opportunities included teacher observation and feedback in class, and evaluation of student artefacts using rubrics. Oral feedback was provided in the next lesson period.

(i) How was the learning sequence adapted?

The **Collision of an egg** SAILS inquiry and assessment unit was implemented in full in this case study. The goal of the activity was to let students apply studied relationships in a practical task. The teacher developed an evaluation plan prior to the lesson period of (double period, 2x45 minutes) taking the goal and the target group into consideration.

The teacher selected a few criteria on the basis of which the performance of the group could be evaluated. The main focus was on the evaluation of the process of *planning investigations* (designing the experiment). The teacher modified the 3-point rubrics for assessment of inquiry skills provided in the unit, using them as a guide but changing the text. The teacher let the students know in class how their work would be evaluated, i.e., that they had to write down their experimental design and predictions, and every group had to show their research proposal to the teacher before starting the experiment. Both the proposal of the group and the conclusions drawn from the experiment were part of the assessment. The teacher took notes during the process and filmed the work of the groups. During the planning phase, the teacher assessed the groups by asking guiding questions.

Lesson sequence

1. First the students listed the factors that would affect the impact on the egg at the point of collision.
2. Next the students worked in small groups to design an experiment to study the forces affecting the egg.
3. Students carried out the experiments that they had designed (implementation of experiment) and recorded their results (Figure 1).
4. Students (in small groups) interpreted their results and made predictions.

Figure 1: Implementation of the experiment.

(ii) Which skills were to be assessed?

The main inquiry skill assessed in this case study was *planning investigations* (carrying out an investigation), but teacher also assessed *developing hypotheses* and *scientific reasoning* (drawing conclusions and critiquing experimental design). Assessment opportunities included teacher observation and feedback and evaluation of experimental plans.

(iii) Criteria for judging assessment data

Scientific reasoning (recognition of variables)

The teacher asked guiding questions to aid the students in identifying variables:

- What physical variables affect the force generated on the object?
- What does momentum depend on?
- How does a change in momentum affect force? What variable can you assign to the quality of the ground?

Based on the responses to these questions, the teacher could assess the ability of students to identify dependent and independent variables.

Planning investigations, developing hypotheses

In this task, the students had to manipulate variables, recognise relationships and develop a hypothesis. They designed an experiment to investigate their hypothesis. The teacher asked guiding questions to aid the students at various points during this task:

- Which variable can be taken to be constant?
- How do you find connections between the variables?
- How can an object's momentum be changed?
- What does the impact speed depend on?
- How does the drop height affect the egg's collision?
- What variable can you change by changing the surface?

The teacher's assessment was based on students' answers to the questions during the planning process and on the experimental plan formulated.

Planning investigations (implementation of experiment)

During this activity, students focused on implementing their experiment, manipulating variables and recording data. The teacher asked guiding questions to aid the students in carrying out the experiments, and based assessment on the students' answers:

- How do you make sure that the egg always has the same speed at impact?
- What data are you going to record?
- How can you observe the result of the force acting on the egg?

Scientific reasoning (drawing conclusions and critiquing experimental design)

Students interpreted their results and made predictions in small groups. They worked together to select the most likely hypothesis in answer to the question of "onto what surface should the egg be dropped from a height of 15 m, to ensure that it would not break?" This encouraged the students to recognise relationships, classify, to think in terms of regularities and to create a model. Assessment was based on students' answers to teacher's questions during the task. The teacher's guiding questions included:

- Based on your results, what surface do you think the egg should be dropped on?
- What variables do you take into account when deciding on the surface affecting the landing of the egg?

(iv) Evidence collected

Teacher opinion

Of the six groups in this class, only two were confident enough to drop the egg in just flour.

Sample student artefacts

Recognition of variables

Group 1

> *Teacher*: ***"How can you keep the speed of the egg constant?"***
> *Student*: ***"I always drop it from the same place."***
> *The group shows the plan*: ***"We'll see how the egg reacts to different materials and we'll drop it from the same height."***

Assessment: Using deductive reasoning, the students put together all available information. They identified the dependent and the independent variables and used rule recognition

Planning investigations

Group 4

> *Student shows the teacher the plan*: ***"We drop the egg from a height of 50 cm, 1 m and 2 m. Using the questions, we try to identify the relationship between the various heights and between the surfaces we drop it on… We have recorded the forces affecting the egg: gravity, weight, drag and the resistance of the ground."***

Assessment: The students identified the relationships between the variables, selected the dependent and the independent variables. When deciding on heights, they did not have any predictions and could not explain the height data. While designing the experiment, the students strove to recognise known regularities and relationships.

Implementation of experiment

Group 3

Students show the plan to the teacher: ***"Do we keep changing the materials under the egg?"*** *Teacher:* ***"What do you change by changing the materials?"*** *Student:* ***"The surface of the collision."***

Assessment: The students in this group have not yet identified the relationships between the variables. They summarised already available information.

Scientific reasoning (drawing conclusions)

Group 1:

The student works in a team: ***"If the egg falls on a paper hanky, the hanky will dent and this should reduce the force."*** and ***"We are planning to put a paper hanky at the bottom of the box, then some flour, then semolina, then another layer of flour, since falling from a height of 2 m, the egg didn't break."***

Assessment: The students formulated a hypothesis and made good use of analogical thinking, but they do not have enough data to establish the rule.

(v) Use of assessment data

After the class, I reassessed the students' work and the activity and during the next class we discussed the experiences of the project and worked together to gather all the data that helped to define a model. The groups were given oral feedback about their work.