4.5 Case study 5 (CS5 Germany)

Concept focus	Determining rate of reaction – altering rate of reaction Handling and identifying gases
Activities implemented	Activities A-C
Inquiry skills	Planning investigations
Scientific reasoning and literacy	Scientific reasoning (identifying variables)
Assessment methods	Classroom dialogue Teacher observation Peer-assessment Student devised materials (reports) Presentations
Student group	**Grade:** 9th grade (lower second level) **Age:** 14-15 years **Group composition:** Co-ed; range of attainment and ability; 19 students (5 girls, 14 boys). **Prior experience with inquiry:** several inquiry tasks concerning mechanics, 2 lessons (90 min) per week for 4 weeks

Students' skills in *planning investigations* and their ability to define and control variables were assessed formatively during this implementation. Assessment was achieved through a combination of teacher observation, evaluation of students' written protocols and peer-assessment of posters outlining experimental plans.

(i) How was the learning sequence adapted?

The activities of the **Reaction rates** SAILS inquiry and assessment unit were carried out in a separate elective interdisciplinary science course. In general, the teacher based the unit on the provided SAILS material, with some modifications. As an introduction to the unit, the teacher threw several fizzy tablets into a glass of water. The research question then was given as proposed: "Which gas emerges from the tablets?" Further questions raised during the introduction were "Which gases do you know?" and "How can you find out which gas emerges from tablets?" Due to the students' lack of chemistry knowledge, the teacher had to add one step after this introduction to the unit. The students had to research the properties of the gases they suggested, such as oxygen, carbon dioxide, methane or ammonia. Without this knowledge about the properties, no further investigations in terms of the unit could have been made, because the students would not have known what to look for.

The students did the planning and execution of an appropriate experiment to investigate the research question without guidance from the teacher. The documentation followed default structures, which are established at this particular school. So the open parts of the inquiry process focussed strongly on planning and executing. *Planning investigations* was definitely influenced by prior lectures (inflate balloon with household articles such as baking powder and vinegar). Therefore the desirable variance of the experimental setups was not given as all groups chose to catch the gas with a balloon. The students worked in groups of three because groups of four students could not ensure that there were tasks for every group member. Gender issues were not addressed, because it was not necessary in any way.

(ii) How were the skills assessed?

The skills that were to be assessed included *planning investigations*, execution of experiment and handling experimental material independently and control of variables. To get feedback during the

inquiry process, the teacher used different forms of assessment. Three different types of assessment were used in a formative manner:

- Observation by teacher during the inquiry: one of the teacher's concerns was to let the students to work on their own and only to intervene when he notices a students' approach that could never work out. No dedicated observation sheets were used.
- Protocols: the protocols recorded by the students followed a standardised format and contained information about the inquiry approach, experimental setups, measured data and conclusions. The teacher reviewed the protocols after the lesson. Each student got individual feedback in form of comments on their protocol sheet. Grades or scores were not given.
- Peer-assessment: the intended experimental setup by each group was shown on a poster before executing the actual experiment. The students took the chance to review and discuss the setups of other groups. Unfortunately, all groups chose a similar setup. The teacher also reviewed safety aspects in student' experimental approaches.

(iii) Criteria for judging assessment data

The main aspects the teacher was looking for were how well the students' skills were developed in particular experimental aspects. Therefore he focused on the following aspects:

- Planning of an appropriate experimental setup
- Organising suitable experimental parts
- Executing the experiment
- Changing only one variable at a time during Activity C: Altering reaction rate, in particular amount and temperature of the water, stirring the water or not stirring, size of crushed tablet pieces, etc.
- Documenting their activities in a given way, ensuring that they are comprehensible for outsiders or after a long time

(iv) Evidence collected

Teacher opinion

The research question was very motivating, some learners even stated that they have been asking this question for themselves for a long time. The learners enjoyed the inquiry a lot. They were all fully engaged in the process. Only some delays occurred, e.g. when students evaluated the time it took the fizzy tablet to disappear.

The teachers emphasised that the success of the unit is partly owed to students' intentional choice of this extra science course. Concerning the learning goals and teacher's expectations, he stated that, "Everything went swimmingly!"

A suggestion for improvement was to implement the already mentioned part, in which students do research about common gases and the properties of those, into the regular unit in whichever form. The peer assessment was not too effective due to the fact, that experimental setups were too similar and therefore students had not much to discuss about.

(v) Use of assessment data

Concerning the technical content, there are no effects predicted to impact upon future lessons. Concerning inquiry skills, however, the students' experimental skills became much clearer due to the focused assessment. In future lessons it will be possible to rely on the skills that were assessed, because a high level of competence can now be estimated more easily. The students' protocols provided useful information to the teacher. An interesting fact is that when reviewing the protocols, the teacher noticed that the students documented their actions and results a bit haphazardly. For example, the setups were not described in as much detail as possible. Is it important to mention that the real setups were a lot better than the documented ones. Also the results and conclusions were

documented imprecisely, whereas in reality, they were a lot more accurate. So sometimes a little gap between the observations and the protocols was discovered. The on-the-fly observations were useful, when the students mixed up different variables instead of keeping every variable except one unchanged.

(vi) Advice for teachers implementing this unit

The most general but useful advice is, to let go and not to interfere. If students' experience allows for it, the opportunity to let them browse a collection of experimental apparatus on their own should be taken.