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Assess Inquiry in Science, Technology and Mathematics Education

ASSISTME

Assessment method description for 'investigations in science' competence

Peer-feedback on identified questions

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1. Summary

This descripiton will introduce a method for formatively assessing students' competence to ask questions. There will be a descripition of what students are expected to do (their task) and how peer-feedback could be provided.

Based on the observation of a phenomenon in science, students develop a research question. They then discuss and correct the questions in groups, so the peers assess. To check and further improve the revised version, they should develop an experimental design.

Subject	• Assessment method generally adaptable to all science subjects (investigations and experiments) • Paradigmatic example in biology; topic: photosynthesis, absorption of light by chlorophyll
School level	• Assessment method generally adaptable to lower and upper secondary level • Paradigmatic example in upper secondary school
Assessed competences	• Identify questions or diagnose problems (in science) Basic standard grade 12: "Students are able to perceive situations and phenomena with several senses, observe them precisely, and describe them using adequate terminology. They can formulate diversified questions based on the aforementioned actions." (taken from ASSIST-ME report D4.7)
Data collection about student learning	• Written data; written answer to open question
Feedback method	• Peer-feedback
Combination with summative assessment	• Paradigmatic example and feedback method for formative assessment, but task generally usable for both formative and summative assessment

Table 1. Main characteristics of assessment method "peer-feedback of identified questions".

2. Description of the feedback method with guidelines how to use it

"Peer-feedback" describes formative assessment which is conducted by student peers. This chapter will provide a description of the principle along with short summaries of different varieties.

In both self-and peer-feedback, it is of central importance that the goal of a task and the criteria of evaluation are understood well by the students (Sadler, 1989; Black et al., 2003). Black et al. (2003) suggest supporting this understanding by showing examples.

Both self-and peer-feedback allow the teacher to freely move between the students and concentrate on individual problems since she / he does not carry the responsibility to do all the assessment of the whole class.

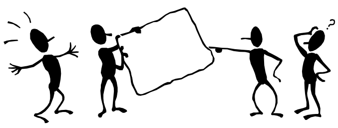
The process of peer- and self-assessing pieces of work from time to time should help the students to bear in mind the aims of their work and therefore assist them in becoming independent learners (Black et al., 2003).

Why you should do this

Peer-feedback follows the idea of "activating students as instructional resources for one another" (Leahy et al., 2005). Peer-feedback is seen as particularly powerful since *"students may accept criticisms of their work from one another that they would not take seriously if the remarks were offered by a teacher. Peer work is also valuable because the interchange will be in language that students themselves naturally use […]"* (Black et al., 2004, p. 14). The same authors find evidence that *"when students do not understand an explanation, they are likely to interrupt a fellow student when they would not interrupt a teacher." (Black et al., 2004, p. 14).*

However, Black et al., 2003, also mention that before being able to assess their peers' work, they have to learn how to behave in groups (listening to others, taking turns) and how to communicate their feedback usefully.

In reciprocal peer-assessment, students undertake both the role of the assessor and the assessee, by assessing each other's work. The rationale lying behind reciprocal peer-assessment is that all the students are given the opportunity to experience both the role of the assessor and the assessee and benefit from both practices. Performing the peer-assessor role requires students to have and practice their assessment skills, namely: defining criteria, judging the performance of a peer, and providing feedback (Sluijsmans, 2002). Students could be supported through the provision of scaffolds while performing each one of these assessment skills. For example, if students are novices in peer-assessing and have no prior experience on how to define assessing criteria or what has to be measured in the learning process and thus compose assessment criteria, they could alternatively be provided with those criteria from the teacher, in order to better execute their task.



3. Paradigmatic example: Biology, upper secondary level

In this chapter, the use of a method for formatively assessing students' competence to ask questions at the very beginning of an investigation will be described. The formative assessment methodology was both inspired by the Maths-conferences (e.g. PIK AS, 2010; Wittmann, n.d.) and by Page Keeley's "question generating" (Keeley, 2008). The example is for a Biology lesson on photosynthesis in upper Secondary level. The example was slightly adapted from Campbell and Reece (2002).

As an introduction, the students are shown a phenomenon. Then, the teacher sets the goal of the lesson - which is to elaborate a good research question with which the phenomenon could be explored and explained. At the beginning of the lesson within a longer unit on photosynthesis, this could be the phenomenon: white light, provided by a slide projector, is sent through a prism. The resulting spectral colours should be shown by holding a white screen into the optical path in front of the prism. Afterwards, the teacher explains that the prism is for making spectral colours. The light is then sent through a cuvette filled with chlorophyll a (which can easily be gained from fresh leaves or can be bought as a solution). The teacher mentions that the cuvette contains chlorophyll and that this is the important part of the experimental design. The spectral colours should be observed again after the light has passed through the chlorophyll (see figure 1). The students will notice that the red and blue parts of the light are missing now. The room should be dark for optimal visibility of the phenomenon.

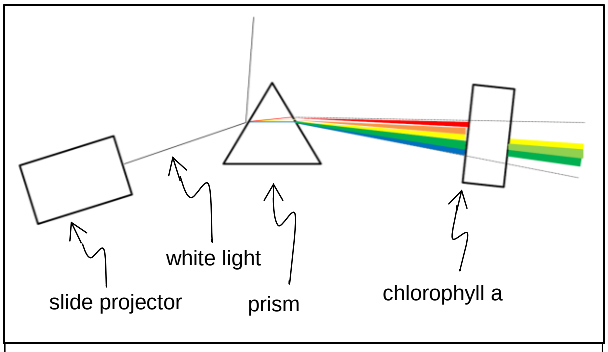


Figure 1. Experimental design.

After just looking at this phenomenon without a specific task, the teacher tells the goal of the lesson: to elaborate a good research question with which the phenomenon could be explored and explained.

The students are shown the phenomenon again. This time, however, they are asked to be very careful in observing what happens to the light while traveling from the slide projector through the prism and the chlorophyll. After having shown the phenomenon, the teacher leads a whole-class discussion on what the students have seen. The aim of this is to establish a common understanding of what was observed.

Tip: Younger students might be provided with the "question generating stems" (taken from Keeley, 2008).

- Why does …?
- How does …?
- What if ...?
- How does … respond to …?
- How does …. compare to …?
- Does … when …?

The students are then given time to think to write down a first research question which could help to explore and explain the phenomenon (this activity was inspired by Page Keeley's "question generating" (Keeley, 2008)).

In the following, all students write down a research question which could help to explore and finally explain the observed phenomenon.

The students compare their research questions in small groups (e.g. 3-6 students). They are encouraged to discuss the differences between their questions. Additionally, the teacher advises them to discuss among each other what they think about the different questions: what questions are good ones, and which ones should be improved - and why. They should give reasons for their statements. Based on this discussion, the members of each group improve the research questions brought up in their group collaboratively. When they discuss and revise questions, the students also write down a first list of "quality criteria of research questions".

As a second step in improving the original research questions, the students - still in the same groups - try to design an experiment which allows exploring and answering the research questions. They may notice that the research questions need further revision. Again, the teacher encourages the students to think about quality criteria of research questions on a meta-level. They are asked to add their thoughts to their list of criteria and/or to edit the original version of their list.

To complete this activity, the teacher collects the favourite research question from each group and compiles a list with all the quality criteria collected by the different groups.

In the next lesson, at least one of the designed experimental should be carried out. For advanced students with a high degree of independence it would also be possible to carry out one experimental design per group.

Finally, the skill of elaborating research questions is practiced in a homework which includes elaborating another research question on a similar phenomenon (e.g., why leaves get red / brown in autumn): students should 1) write down a question, 2) check and improve it with the elaborated criteria, 3) develop a suitable experimental / investigational design.

4. Assessment criteria of a question

The following paragraph gives an overview of different quality criteria that could be mentioned as "quality criteria of a question". A similar list might be the outcome of the students' work on their questions as described in the earlier chapters.

Content-related criteria:

- The research question is directly related to the observed phenomenon (in the example on photosynthesis: the research question is directed at the absorption of red and blue light, not on the functioning of the slide projector or similar).
- The research question is interesting; the answer is not obvious from what the students learned in the previous lessons of the course.
- It is possible to explore the research question with subsequent investigations or experiments with the tools, measurement instruments, materials which are available at the school.
- It is possible to define measurable independent and dependent variables linked to the question.
- [Criteria added by the students]
- …..

Formal criteria:

- It is easy to understand the research question language-wise: it is short, clear, simple.
- The research question does only consist of one single question (in the example of photosynthesis: "does chlorophyll absorb red light?" instead of "does chlorophyll absorb red portions of light and get warm when exposed to light?")
- The research question has one of the following structures: "Does factor A affect factor B?"; "How does factor A affect factor B?".
- ….

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