Report from the FP7 project:

Assess Inquiry in Science, Technology and Mathematics Education

ASSISTME

Assessment method description for 'investigations in science' competence

On-the-fly assessment of deduction of general laws from given experimental results

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Delivery date	15th August 2014
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Dissemination level	PP

1. Summary

This descripiton will introduce a method for assessing students' competence to deduct general laws from given experimental results at the end of an inquiry session. There will be a descripition of what students are expected to do (their task) and how the working process could be formatively assessed.

The students conduct experiments in order to answer an open-ended question. The experimental results are collected and discussed, so that everybody knows about all results. Students should then try to generate a rule which explains all the results - on a level of abstraction that is appropriate for their age.

If the students do not know what to do or get stuck at some point, they should be offered prompts which help them to get to the next step, but which do not tell them the correct answer.

Once the first version of rule(s) is formulated, the students should test this rule with new data. This is to check if the first version of rule(s) was/were correct or what parts of the rule(s) should be adapted so that they also cover these new cases.

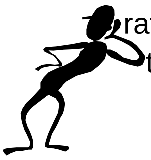
Subject	• Assessment method generally adaptable to all science subjects (investigations and experiments), to mathematics • Paradigmatic example in integrated science; topic: buoyancy
School level	• Assessment method generally adaptable to all school levels • Paradigmatic example in primary school level
Assessed competences	• Developing explanations (in science) Basic standard grade 6: " Guided by the teacher, students can identify simple structures and patterns in a restricted amount of data and can formulate their findings as general rules in every-day-language." (taken from ASSIST-ME report D4.7)
Data collection about student learning	• Performance and written student data
Feedback method	• On-the-fly
Means of assessment	• Description, guidelines and paradigamtic example for formative assessment

Table 1. Main characteristics of assessment method "On-the-fly-assessment of deduction of general laws from given experimental results ".

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

The feedback method "interactions on-the-fly" describes informal formative feedback.

"On-the-fly formative assessment arises when a "teachable moment" unexpectedly occurs, for example, when a teacher circulating and listening to the conversation among students in small groups overhears a students say that, as a consequence of her or his experiment, 'density is a property of the plastic block and I doesn't matter what the mass or volume is because the density stays the same for that kind of plastic.' The teacher recognizes the student's grasp of density and challenges the student with other materials to see if she or he and her or his group-mates can generalize the density idea." (Shavelson et al., 2008, p.300).



Ruiz-Primo and Furtak (2004), Ruiz-Primo and Furtak (2006a), and Ruiz-Primo and Furtak (2006b) describe typical assessment conversations as a four-step cycle, where the teacher elicits a question, the student responds, the teacher recognizes the student's response, and then uses the information collected to guide and assist student learning (see figure 1). 'Eliciting' means evoking, educing, bringing out, or developing. To describe a teacher's actions as eliciting during informal formative assessment is thus an accurate description, as teachers are calling for a reaction, clarification, elaboration, or explanation from students. Typical examples of such eliciting questions include "Why do you think so?" or "What does that mean?" (Ruiz-Primo & Furtak, 2006b). During informal formative assessment, teachers must react on the fly by recognizing whether a student's response is a scientifically accepted idea and then use the information from the response in a way that the general flow of the classroom narrative is not interrupted (e.g., calling students in the class to start a discussion, shaping students' ideas).

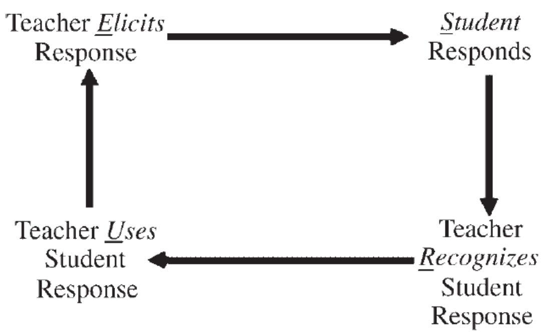


Figure 1: The ESRU model of informal formative assessment (taken from Ruiz-Primo and Furtak (2006).

3. Paradigmatic example: science, primary school level

In this chapter, the use of a method for formatively assessing students' competence to deduct general laws from given experimental results at the end of an inquiry process will be illustrated by an example. The example is for an integrated Science unit on buoyancy at primary school level, it was inspired by Bass et al. (2009).

The students investigate buoyancy with a glass of water, salt and an egg. They are told to put the egg into the glass of water and see what happens to the egg. They are then told to add salt and see what happens to the egg. The teacher makes sure that everybody understands that this is the question to be investigated: the relation between the amount of salt in the water and the position of the egg in the water. To as a means of scaffolding, the teacher could start with a table on the blackboard which says:

Amount of salt in the water glass	Location of the lower end of the egg in the water glass
0	On the glass bottom
1 spoon	….
2 spoons	….
…	

Tip: it might be interesting to discuss in class how the amount of salt and the location of the egg could be measured and documented.

While the students are working, the teacher has time to walk around and listen to what students are discussing. He / she takes the opportunity to interact with individual students and groups by asking questions (e.g. "what does that mean", "why do you think so") and to inform herself / himself about the students learning this way. The teacher also responds to the students statements by giving feedback and guiding their further learning (for details, see chapter "description of the feedback method with guidelines how to use it").

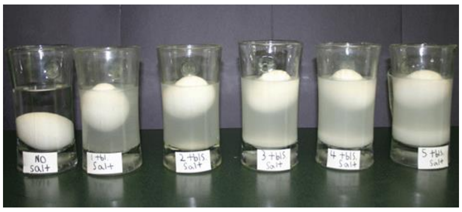


Figure 2: buoyancy experiment with eggs. Picture taken from http://physics.stackexchange.com/questions/59962/how-dense-fluid-affect-the-buoyancy-force.

After a few measurements, the students are asked to conduct the same experiment with a different body - e.g. a bit of plastic modelling mass, a junk of aluminium foil, a solid piece of wood, a toy car. Again, they should record the amount of salt added and the position of the body in the glass. This will be another moment for on-the fly assessment: while the students are working, the teacher has time to listen to what students are discussing, to interact with them and to provide feedback (for details, see chapter "description of the feedback method with guidelines how to use it").

Then, the students are asked to summarize their findings as a rule in one sentence with the structure "the more…, the … ." They should then self-check their finding by applying the rule to a new experiment, e.g. in a larger glass container. If the rule does not apply to this new experiment, it should be adjusted. This will be another moment for on-the fly assessment: while the students are working, the teacher has time to listen to what students are discussing, to interact with them and to provide feedback (for details, see chapter "description of the feedback method with guidelines how to use it").

4. Teacher's strategies for assessment

The following table displays typical teacher's strategies for the different dimensions of the ESRU cycle (compare to the first chapter).

Eliciting	Recognizing	Using
Epistemic frameworks		
Teacher asks students to:	Teacher:	Teacher:
• Compare/contrast observations, data, or procedures	• Clarifies/Elaborates based on students' responses	• Promotes students' thinking by asking them to elaborate their responses (why, how)
• Use and apply known procedures	• Takes votes to acknowledge different students' ideas	• Compares/contrasts students' responses to acknowledges and discuss alternative explanations conceptions
• Make predictions/provide hypotheses	• Repeats/paraphrases students words	• Promotes debating and discussion among students' ideas/conceptions
• Interpret information, data, patterns	• Revoices students' words (incorporates students' contributions into the class conversation, summarizes what student said, acknowledge student contribution)	• Helps students to achieve consensus
• Provide evidence and examples	• Captures/displays students' responses/explanations	• Helps relate evidence to explanations
• Relate evidence and explanations		• Provides descriptive or helpful feedback
• Formulate scientific explanations		• Promotes making sense
• Evaluate quality of evidence		• Promotes exploration of students' own ideas
• Suggest hypothetical procedures or experimental plans		• Refers explicitly to the nature of science
• Compare/contrast others' ideas		• Makes connections to previous learning
• Check students' comprehension		
Conceptual structures		
Teacher asks students to:		
• Provide potential or actual definitions		
• Apply, relate, compare, contrast concepts		
• Compare/contrasts others' definitions or ideas		
• Check their comprehension		

Table 2: Typical teacher's strategies for the different dimensions of the ESRU cycle. Taken from Ruiz-Primo and Furtak, 2006.

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