Report from the FP7 project:

Assess Inquiry in Science, Technology and Mathematics Education

ASSISTME

Assessment method description for 'modeling in Technology' competence

Interactions on-the-fly on oral presentations and concept maps

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Delivery date	31th December 2014
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Dissemination level	PP

1. Summary

This description will provide ideas and inspiration on how to formatively assess 'modeling competence' using the interactions on-the-fly method. There will be a description of what students and what the teacher are expected to do (their task) and how students' learning working process could be formatively assessed.

The interactions on-the-fly assessment method could be used in many fields of competence. Here the focus lies on the modeling competence in a paradigmatic example in Technology Education.

Subject	• Modeling competence generally integrateable in all science subjects, in mathematics and technology education. • Paradigmatic example in Technology topic: "*what is technology*" lesson of 45 minutes.
School level	• Modeling competence applicable in lower and upper secondary education level • Paradigmatic example in lower secondary school level
Assessed competences in the paradigmatic example	In modeling "Model construction (Stratford, Krajcik, & Soloway, 1998); model use (NRC, 2012); comparison between models (Penner, Giles, Lehrer, & Schauble, 1997); model revision (Schwarz & White, 2005) and model validation have been identified as the practices in which students can be usefully engaged during modelling" (taken from ASSIST-ME report D4.7)
Data collection about student learning	• Students' oral presentations and concept maps
Feedback method	• Interactions on-the-fly
Combination with summative assessment	• Description, guidelines and paradigmatic example for formative assessment, assessment criteria also usable for summative assessment.

Table 1. Main characteristics of assessment method "Interactions on-the-fly on modeling in students' oral presentations and concept maps".

2. Modeling competence

Modeling in Technology could be interpreted with many different ways. For example, modeling could be expounded as *engineering design in technology* which involves four groups of sub-competences. The first group of sub-competences describes the preparation for engineering design. It involves defining and delimiting a problem, need or desire, identifying constraints and criteria, investigating relevant information, generating and evaluating possible solutions, analysing alternatives, selecting a potential solution, justifying the decision. The second group of sub-competences refers to the realization of engineering design. It involves planning design of prototype, constructing prototype (using suitable tools/materials), testing prototype by collecting, analysing, interpreting and representing data. The third group of sub-competences involves the evaluation of engineering design. This includes evaluating prototype against the criteria, reasoning, modifying the design and redesigning if necessary. The fourth sub-competence is communicating at all stages of the process. All these sub-competences resemble the corresponding sub-competences of *modeling in Science* (see figure 1). In an attempt to avoid such confusion between those two concepts of *modeling* and *engineering* in the domain of Technology, we propose an alternative example to illustrate the modeling competence in Technology, in the way that *modeling competence* has been defined by the partners of this project. In particular in this example we focus on the meta-knowledge part of the modeling competence, as presented in figure 1.

3. Description of the assessment method with guidelines how to use it

The feedback method "interactions on the fly" describes formative feedback which is conducted based on oral activities. This chapter will provide a description of the principle along with short summaries of different varieties.

The feedback method "interactions on-the-fly" describes informal formative feedback. This chapter will provide a description of the principle along with short summaries of different varieties.

Principle of interactions on-the-fly

"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).

Complementary to 'on-the-fly formative assessment' is 'planned-for-interaction formative assessment'. Planned-for-interaction formative assessment includes marking (see chapter 6.2 of D4.7); peer- and self-assessment (see chapter 6.3 of D4.7); open classroom discussion and structured classroom dialogue (see chapter 6.4 of D4.7).

Varieties (non-exhaustive list)

Assessment conversation (Duschl, 2003; Duschl & Gitomer, 1997; Ruiz-Primo & Furtak, 2006)

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 student learning (see figure 3). '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).

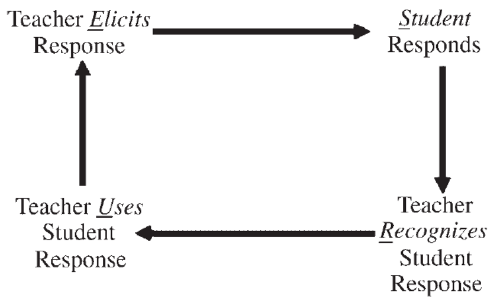

Figure 2: The ESRU model of informal formative assessment (taken from Ruiz-Primo and Furtak (2006).

(Taken from ASSIST-ME report D4.7, p. 18-20)

4. Paradigmatic example: Technology, lower Secondary level

In this chapter, the use of a method for formatively assessing students' competence in creating a mental model of *what is technology* will be illustrated by an example. The example is addressed for students of lower secondary school level and it is inspired by a model proposed by Ropohl (1979).

The idea of this task is to initially request from students, who work in groups, to brainstorm their ideas about "*what is technology*" and create a concept-map based on those ideas. In a lesson of 45 minutes, a time of 20 minutes could be given to students to create this concept map in an A3 empty worksheet. As the next step, the teacher could lead the class to a whole class discussion, in which each group will have to present its concept-map. The purpose of this discussion would be to reach to a cognitive model of "*what is technology*". During this discussion, the teacher could formatively assess students using the method *interactions on-the-fly.* For doing that, the teacher could promote students' thinking by asking them to elaborate their response using questions like "why?" and "how?" Also the teacher could ask for examples and/or evidence that support students' mental model about *what is technology*. The teacher could also compare and contrast response from different groups and therefore promote the debating and discussion among students' ideas about *what is technology*. Previous research has shown that students of elementary school level usually reply to the question of *what is technology* by focusing on the construction of artefacts by humans and to the process of improving things (Moreland, Moreland, Jones, & Barlex, 2008). But "*technology is not only about artefacts; it is also how and why those artefacts are developed and the impact that they may have on people and our world*" (Moreland, et al., 2008; p. 6). In that case, the teacher could offer opportunities to students for broadening their ideas. For doing that, a first step could be that based on the oral presentations of the students, the teacher could note down all the ideas in the blackboard; therefore trying to gather together all the information derived by students' presentations.

The teacher could consider mental models of Technology proposed by other researchers. A commonly shared concept of *what technology is* in the area of Germany and Switzerland, proposed by Ropohl (1979) (see figure 3). A translation of this model is provided as well (see figure 4). This model has three main dimensions: conditions (circumstances that create the need for developing a technical object), technical objects (the actual objects produced by humans because of certain needs), and consequences (of using the produced technical objects). The consequences of this model may affect the initial conditions. Therefore this process is not linear but circular. Also conditions and consequences have natural, human and social implications.

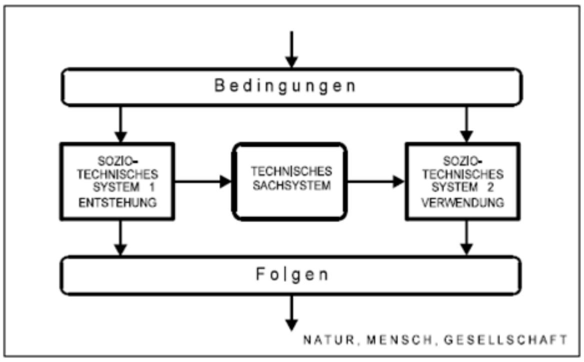

Figure 3: *Literatur*: Ropohl, G. Allgemeine Technologie: Eine Systemtheorie der Technik. 3rd ed. of the 1979 book, Karlsruhe: Universitätsverlag 2009; http://digbib.ubka.uni-karlsruhe.de/volltexte/1000011529

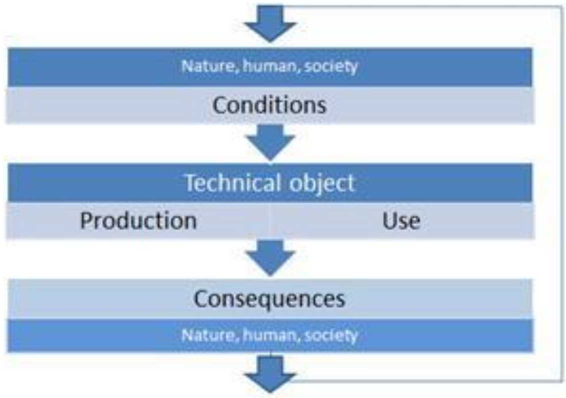

Figure 4: *Translation of the model proposed by Ropohl (1979).*

During the oral presentations by students, the teacher could have in mind the aforementioned model. While noting to the blackboard students' ideas, as mentioned above, the teacher could cluster students' ideas on the basis of the three dimensions (conditions, technical objects, consequences) and pose appropriate questions to students to stimulate their thoughts in regard to the discussion topic *what technology is.*

Overall in this task the students will not be involved in activities of designing a model themselves based on a problem given or engineering oriented tasks, but they should rather focus on sharing their knowledge and understanding of what technology is, what the nature of technology is and thereby students will be engaged in a process of creating a mental model around the concept of *what technology is.* This becomes an essential part of Technology Education, whose learning outcomes involve not only doing but also knowing about technology. Procedural and conceptual aspects are equally important in teacher and students formative interactions (Moreland, et al., 2008). In this example, students could develop and practice their meta-knowledge competences and in particular their metacognitive knowledge about the process of modeling technology. In other words, this task should focus on students' ability to explicitly, describe and reflect on the actual process taking place in technology, on their knowledge about the nature and the purpose of technology, thereby creating a mental model of technology itself.

5. Assessment criteria

The following table displays typical teacher's strategies for the different dimensions of the ESRU cycle (see figure 2 for more information).

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 (Ruiz-Primo & Furtak, 2006).

6. References

Duschl, R.A. (2003). Assessment of inquiry. In J.M. Atkin & J.E. Coffey (Eds.), *Everyday assessment in the science classroom* (pp. 41–59). Washington, DC: National science Teachers Association Press.

Duschl, R.A., & Gitomer, D.H. (1997). Strategies and challenges to changing the focus of assessment and instruction in science classrooms. *Educational Assessment*, 4, 37–73.

Moreland, J., Moreland, J., Jones, A., & Barlex, D. (2008). *Design and Technology Inside the Black Box: Assessment for learning in the design and technology classroom*. Granada Learning.

Papaevripidou, M., Nicolaou, C. T., & Constantinou, C. P. (2014). On Defining and Assessing Learners' Modelling Competence in science Teaching and Learning. Paper presented at the Annual Meeting of American Educational Research Association (AERA), Philadelphia, Pennsylvania, USA.

Ropohl, G. Allgemeine Technologie: Eine Systemtheorie der Technik. 3rd ed. of the 1979 book, Karlsruhe: Universitätsverlag 2009; http://digbib.ubka.uni-karlsruhe.de/volltexte/1000011529

Ruiz-Primo, M.A., Furtak, E.M (2006a). Exploring teachers' informal formative assessment practices and students' understanding in the context of scientific inquiry. *Journal of research in science Teaching*. 44 (1), p. 57 - 84.

Ruiz-Primo, M.A., Furtak, E.M (2006b). Informal formative assessment and scientific inquiry: exploring theachers' practices and student learning. *Educational Assessment* 11 (3& 4), 205-235.

Ruiz-Primo, M.A., Furtak, E.M (2004). Informal formative assessment of students' understanding of scientific inuiry. CSE Report 639. University of Californina.

Shavelson, R.L., Young, D.B., Ayala, C.C, Brandon, P.R., Furtak, E.M., Ruiz-Primo, M.A, Tomita, M.K., Yin, Y. (2008). On the impact of curriculum-embedded formative assessment on learning: a collaboration between curriculum and assessment developers. *Applied Measurement in Education*, 21: 295 - 314.