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Assess Inquiry in Science, Technology and Mathematics Education

ASSISTME

Assessment method description for 'modeling' competence

Self- and peer-feedback on students' concept maps

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1. Summary

This descripiton will provide ideas and inspiration on how to formatively assess 'modeling competence' using the self-assessment 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.

Self-assessment certainly could be used in many fields of competence. Here the focus lies on the modeling competence in a paradigmatic example in Science.

Subject	• Modeling competence generally integrateable in all science subjects, in mathematics and technology education. • Paradigmatic example in Integrated Science unit: designing a CO_2 friendly house, the duration of the whole mission is approximately 20 hours; the activity described in this example could last 2 x 40 minutes.
School level	• Modeling competence integrateable in lower and secondary education level • Paradigmatic example in elementary 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' concept maps
Feedback method	• Self- and peer- assessment
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 "Self- and peer-feedback on students' concept maps**"**.

2. Modeling competence

Modeling is the process of constructing and using scientific models (Hestenes, 1987) and it is considered an integral part of science (NRC, 2012). Efforts to design modelling-based learning (MBL) instruction have relied on a theoretical framework about the modelling competence, which analyses its constituent components into two broad categories, namely *modelling practices and meta-knowledge* (figure 1). Underlying this framework is the idea that student modelling competence can emerge as a result of active participation in specific modelling practices and can be reinforced by meta-knowledge about models and modelling (2009). 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. Meta-knowledge, on the other hand, is analysed into the metacognitive knowledge about the modelling process; this refers to student ability to explicitly describe and reflect on the actual process of modelling, but also on the knowledge about the nature and the purpose of models (Schwarz & White, 2005). In other words, this framework posits what scientists do during modelling and at the same time what we want students to do, so as to be modelling competent.

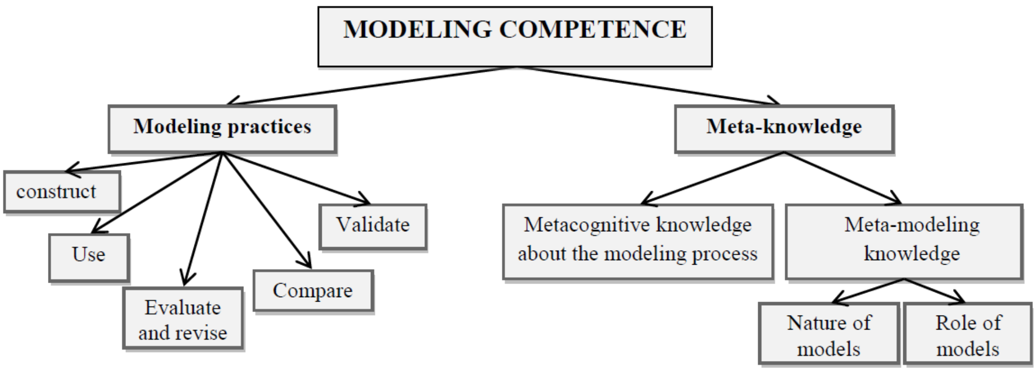

Figure 1: Modelling Competence Framework (Papaevripidou, Nicolaou, & Constantinou, 2014).

(Taken from ASSIST-ME report D4.7, p. 43)

In addition *modeling* in science education places emphasis on the construction and application of conceptual models of physical phenomena as a central aspect of learning and doing science (Hestenes, 1987; Wells et al, 1995; Hestenes, 1997 as cited in Jackson, Dukerich, & Hestenes, 2008). A way of depicting students' conceptual models about physical phenomena is through the construction of concept maps. Concept maps stand as graphical tools which could be used to organize and represent conceptual knowledge and in particular concepts related to a specific phenomenon and the relationships between them (Novak, & Cañas, 2008).

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

The feedback method "self- and peer-assessment" describes formative assessment which is conducted by the learner him/herself or 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).

Principle of self - asssessment

Self-assessment means that each student reflects on the quality of his / her own work, or on his / her understanding of a topic that is just being discussed, or on his / her performance, or similar.

Varieties of self-assessment (non-exhaustive list)

Self-assessment rubrics (Burke, 2006; Arter & McTighe, 2001; Moskal, 2003; Smit & Birri, 2014)

The system is exactly the same as with scoring rubrics: again, the rubric consists of a list of relevant criteria indicating what counts that students should show to demonstrate various levels of performance. However, this time, it is not the teacher who decides on the level of performance but the student who assesses himself / herself.

Varieties of peer - feedback (non-exhaustive list)

Reciprocal peer-feedback

Reciprocal (or two-way) peer-feedback is the type of feedback which emerges when students get involved with a reciprocal peer-assessment setting. In r*eciprocal* 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.

Both assessment methods chosen for this paradigmatic example (self- and peer-feedback) incorporate features of the feedback method *marking (grading and written comments).* As described in more details later on, the written self- and peer feedback are given through the use of a rubric (see subchapter *Assessment criteria for students' artifacts*) in which students are required to assign a score as well as to give a qualitative comment supporting the assigned scoring both while assessing themselves (self-feedback) but also while assessing others (peer-feedback).

"Rubrics articulate the expectations for an assignment or a learning goal by listing the relevant criteria the teacher looks for, or what counts that students should show to demonstrate various levels of performance." The peers in that case "indicate the student's scoring by placing a cross in the correct level of performance". "Written comments should identify what has been done well and what still needs improvement, and give guidance on how to make that improvement (Black et al., 2003). The same authors explain that simple 'good', 'well done', etc. is not sufficient since these general evaluations do not say what has been achieved nor what should be the next steps to be taken" (taken from ASSIST-ME report D4.7, pp 21).

4. Paradigmatic example: Integrated Science, elementary school level

In this chapter, the use of a method for formatively self-assessing students' web-portfolios will be illustrated by an example. The assessment methods used in this paradigmatic example are self-feedback and peer-feedback. This example is inspired by a teaching material developed for the purposes of the SCY project (Science Created by You; for more information see http://www.scy-net.eu/; de Jong et al., 2010; 2012). The SCY-Lab learning environment follows a pedagogical approach that centres on products/ artefacts, called “emerging learning objects” (ELOs), which are created by students. SCY-Lab provides students with dedicated tools for tasks that create ELOs such as modelling, concept mapping, writing reports, gathering data from simulations, and analysing data tables. For the purposes of this paradigmatic example, we focus on one of the four available socio-scientific oriented “missions” offered in SCY-Lab (the general SCY learning environment) and more specific the “friendly house mission 1” which revolves around the reduction of CO_2-emission. In particular students in this context are working toward a solution for this problem by designing a CO_2-friendly house. In this scenario students are called to design an artefact that represents a solution to a complex societal problem related to the students’ own reality. Starting from a complex problem, students work in small groups to identify relevant aspects of the problem, and translate thus-acquired knowledge into a theoretical model (e.g., a concept map). This theoretical model, in turn, forms the basis for the design of an artefact that embodies the groups’ initial solution to the problem. Artefacts are gradually improved through iterative rounds of self-assessment and reflection; the final artefact is presented in a whole-class activity. All students’ artefacts are selected to their web-portfolios. Therefore students’ web-portfolios are constituted by a number of learning objects created by them during the study of the teaching material. Students are given the opportunity to reflect over self-created learning objects that represent the knowledge and/or skills developed during the learning sequence.

After a short introduction by the teacher, students are given with the problem/challenge of the mission, while working in the SCY-Lab platform. The challenge is the following: “*Your job is to design a CO_2-friendly house. So you have to think of all kinds of measures and applications that will reduce the CO_2-emissions of your house. But, although the reduction of CO_2-emissions is the central issue, your house has to provide room and a reasonable level of comfort for a family of four members (two parents and two children).”* (Geraedts, et al., 2010). For the purposes of this paradigmatic example a short description the first activity that normally takes place in this mission will be described along with a description of the assessment method embedded.

Students should first try to identify the different concepts involved in the mission. Their efforts result in a theoretical model (e.g., a concept map) that links these elements together and could be used as basis for generating hypotheses they could be further investigated. Also students are instructed to take into consideration factors that should be taken into account while calculating their carbon footprint, so as to construct a house with the less possible CO_2 emissions. The idea is to have a brainstorm about related concepts that should be taken into account while designing a CO_2 friendly house. Students could end up with a list of ideas as the following: thermal models representing energetic needs of a house, architecture, climate, materials and insulation, outside thermal contributions (air temperature, solar radiation and wind), inside thermal contributions (heating/cooling appliances, electrical appliances, inhabitants) etc.

The mission targets to the acquisition of several learning goals: general science skills (constructing a dynamic model, writing correct hypothesis etc.), general social and presentational skills, general science concepts (Physics- thermodynamics/ electricity/ energy, Biology –carbon cycle, Mathematics- geometry/ verbal). In this example we only focus on students' initial knowledge when modeling a CO_2 friendly house and therefore students' ideas could be related to any of the aforementioned aspects.

For creating the concept maps a c-map tool is offered. The idea of this assignment is to gather together students' ideas in a concept map. A concept map is a graphical representation of important concepts (in boxes), and the relations between those concepts (represented by labelled arrows). The purpose of making a concept map is two-fold: teachers can use the concept maps to assess their students' understanding on the related concepts and their relationships but also to assess the modeling competence of the students while building a theoretical model. Students are given the opportunity to refine their concept maps after the self- and peer- assessment phase and generally during the going-over of the mission. The teacher is given the opportunity to implicitly assess the aforementioned aspects while students fill in the rubric which serves as a self-reporting tool during the self-assessment phase but also as a peer-reporting tool during the peer-assessment. In practice, students could be asked to self-assess their initial concept map, right after its first creation, using the rubric provided. Right after the students could be engaged in a peer-assessment task and be asked to assess a peer's concept map, using a very similar rubric to the first one (the difference could be the salutation from the first to third the person). Then, the students could be given time to review at the same time their own self-reporting rubric but also their peer's feedback and decide for the actions to be taken (possible revisions). While students' enact self- and peer-assessment, the teacher has the prospect to implicitly assess students' understanding and competences while walking around the class and acting as a facilitator when needed.

5. Assessment criteria for students' artifacts

I list of learning goals (general science skills, general science concepts etc.) is given to the students, which should be reached during the mission. Those learning goals are treated here as assessment criteria. Students get aware of these learning goals and are asked to reflect on a selection of skills and knowledge but also use these goals to assess their peers' work.

The assessment criteria provided in the rubric concern: the representational power of the conceptual model (inclusion of objects, variable quantities, processes, relations) (see criteria 1.1-1.2), its interpretive power (the story/mechanism behind it) (see criteria 2-3) and its predictive power (see criteria 4-6). Objects and variables could be presented in a concept map is boxes as the "concepts" whereas processes and interactions could be represented as the "relationships" between concepts through the use of arrows. For that reason the objects and variable quantities are grouped together as one criterion and processes and relations as another respectively.

Table 1. Example of a rubric with learning goals to be assessed for self- and peer/ assessment purposes

	1: dissatisfied, 4: satisfied				Explain your reasoning
Learning goals to be reached at the end of this mission	1	2	3	4	Comments
1. The conceptual model of a CO_2 friendly house includes all necessary components to be considered: 1.1 Objects and variables (E.g. house itself/ devises/environment/ resources, energetic needs of a house, architecture, climate, materials and insulation, outside thermal contributions, inside thermal contributions, etc.)					
1. The conceptual model of a CO_2 friendly house includes all necessary relationships to be considered: 1.2 Processes and interactions					

(E.g. usages of electrical devises, inside thermal contributions and energetic needs of the house etc.)					
2. The theoretical model of a CO_2 friendly house is ruled by an underlying mechanism which could be used to calculate the carbon footprint.					State here which is the mechanism: ______________________ _______________
3. The underlying mechanism that rules the model is scientifically correct.					
4. Using the model we could estimate the house's carbon footprint, when changing the insulation of the house.					
5. Using the model we can estimate the house's carbon footprint, when changing the type of resources used (renewable/ non-renewable).					
6. The model can be used for prediction purposes. For example this means that the model could be used to predict which the carbon footprint of a house is when insulating materials are being added to the house.					
7. Criteria added by students.					

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