FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Who has the juiciest apple? – Planning, performing and recording an experiment about the surface-to-volume ratio

Subject:	Science (Biology)
Age of students:	12 - 14 years
Hardware:	Tablet (or Laptops, or Pcs)
Software:	Interactive PowerPoint presentation
Functionalities:	Providing an Interactive Environment
Time:	90 minutes (experiment) + 45 minutes (discussion time)
FaSMEd partner:	University of Duisburg-Essen
Short Abstract:	The students solve a problem by designing and performing an experiment. Additional cards assess through the experimental steps by evaluating their own competencies and provide help regarding the individual learning pathway.

UNIVERSITÄT DUISBURG ESSEN

Open-Minded

1. Content

The students examine in a student-related context the effects of the surface-to-volume ratio on the evaporation of liquid in apples. The surface-to-volume ratio is a basic knowledge which is used in various contexts (e.g. the surface of bowel or Bergmann's rule).

2. Activity

2.1 Aims

Scientific Goal

In this lesson unit the students will plan, perform and record an experiment about the surface-to-volume ratio. The students plan independently a suitable experiment including the creation of a proper scientific hypothesis and the evaluation of the results by creating a diagram. Therefore, they can conclude that the apple skin and the low surface-to-volume ratio ensure less water evaporation.

Educational Goal[1]

The students can …

(Experiment)

- plan, structure and communicate their work alone or in a team
- develop questions that can be answered through biological knowledge and studies
- perform and protocol simple quantitative experiments and studies
- develop hypotheses, plan appropriate studies and experiments for validation, perform them in compliance with safety and environmental aspects and evaluate them with reference to the hypotheses

(Graph)

- document and present the progress and result of their work appropriately to the situation and audience by using graphs
- illustrate data adequately with mathematical design possibilities

[1] Based on German Curriculum in North Rhine-Westphalia

(Evaluation)

• interpret and explain data as well as trends and draw appropriate conclusions

2.2 Possible applications in the classroom

The material was used in 7th grades with pupils who were 12 to 13 years old. However, the material is subject-independent, so depending on the performance and competence level of the class the material may be used for younger or older students.

Before the students start with the problem and their own experiment the concept of the material should be presented. Depending on the use of the digital or paper-based version, the concept should be presented exemplary in plenary. Afterwards the students get the worksheet and the materials. They can now start with their work in individual, partner or group work.

During the working phase, the students work independently on the problem solution. The teacher should avoid to give assistance (except for methodical and technical questions).

Concepts are used during the working phase, either by the individual students or the teacher, and serve a continuous diagnosis of the learning progress and arising difficulties (formative assessment). The available materials guide through the steps and deal with specific problems of the students which are to be clarified in the situational context.

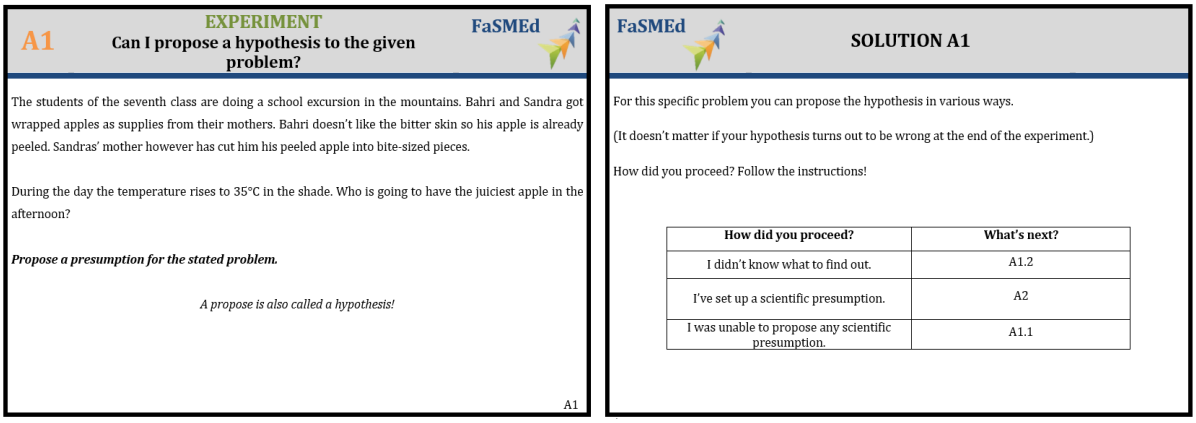
If the students work on their tasks using **self-diagnosis** tools, they will be offered a variety of context-sensitive aid cards („Good to know“ cards), which help with individual difficulties or problems and provide further information. Therefore, the students have to diagnose their own difficulties in individual or partner work independently and select an appropriate aid card which includes content-bound support and solutions.

2.3 Structure/ Methodology

In this concept the students should diagnose the individual learning success and encountered problems by the use of task accompanying printed or virtual cart set consisting of diagnostic and “Good to know” cards. Unlike the teacher diagnosis the students can use the cards with individual problems without having to rely on the teacher or other classmates. Also further examples on the cards can contribute to the understanding and explanations can be read in an individual pace.

Initially the students start with the initial diagnosis card (A1). These diagnosis cards lead step by step through the steps of the tasks. On the front of the printed card you can find tasks and explanations. These tasks should be answered by the students on their own without any

additional help. Then the students rotate the diagnostic card and diagnose their actions on the back by assigning their work result to a case in a table. In the virtual version this is replaced by a click. These take the students either to a continuative “Good to know” card (A1.1 or A1.2) or to the next task with the associated diagnosis card (A2).



A1 EXPERIMENT
Can I propose a hypothesis to the given problem?
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The students of the seventh class are doing a school excursion in the mountains. Bahri and Sandra got wrapped apples as supplies from their mothers. Bahri doesn't like the bitter skin so his apple is already peeled. Sandras' mother however has cut him his peeled apple into bite-sized pieces.

During the day the temperature rises to 35°C in the shade. Who is going to have the juiciest apple in the afternoon?

Propose a presumption for the stated problem.

A propose is also called a hypothesis!

A1

FaSMEd SOLUTION A1

For this specific problem you can propose the hypothesis in various ways.

(It doesn't matter if your hypothesis turns out to be wrong at the end of the experiment.)

How did you proceed? Follow the instructions!

How did you proceed?	What's next?
I didn't know what to find out.	A1.2
I've set up a scientific presumption.	A2
I was unable to propose any scientific presumption.	A1.1

Figure 1: Exemplary diagnosis card front and back

If the students get to a „Good to know“ card, they can find additional help which is useful to answer the task on the previous diagnosis card. Additional examples or explanations contribute to a better understanding and allow the students to generate productive knowledge from past mistakes.

The following figure 2 the use of diagnostic and „Good to know“ cards. The student starts with the overview map A0 to find an entry point where he or she needs additional help. The diagnostic card (Ax) refers to either a “Good to know” card (Ax.y), if further assistance is needed, or to the next diagnostic card if the student does not need any further assistance.

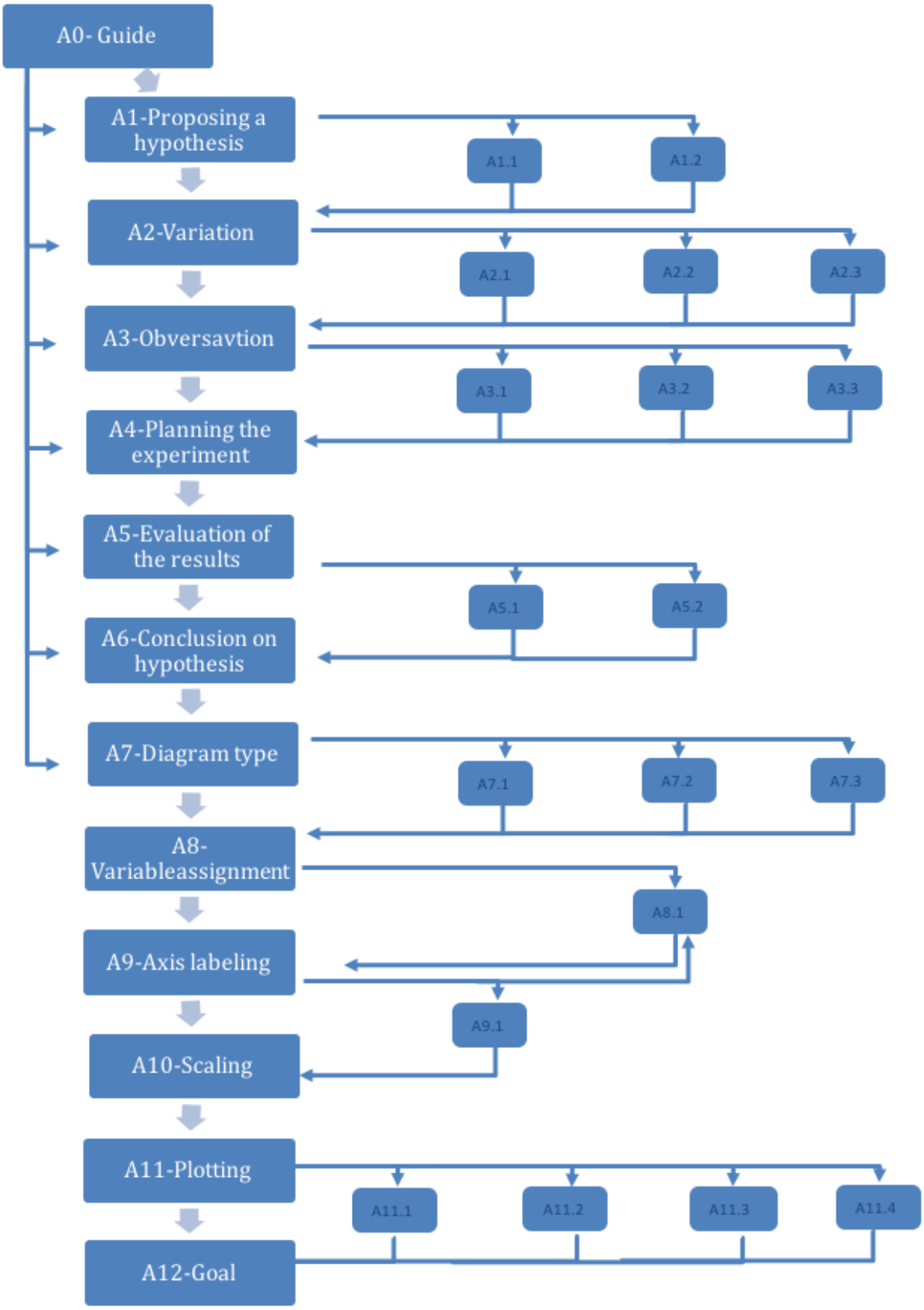

Figure 2: Structure of the disgnostic and "Good to know" cards

2.4 Technology

The digital tool for formative self-assessment is an interactive presentation and to be used with presentation software like Microsoft PowerPoint or Apple Keynote. Due to the big touch screen, it is best to be used on iPads, but also works on Computers and mobile devices.

The tool gives the students the opportunity to explore the experimental steps based on their individual misconceptions, interest and learning pace. It is designed to provide an *interactive environment* as the interactive hyperlink structure facilitates individual learning pathways.

2.5 Aspects of Formative Assessment

The material fulfills four formative strategies: On the one hand the material is used for *clarifying learning goals and criteria* for success because the students try to achieve the specific learning goal for the particular experimental step in group work, which is shown on the first page of each diagnostic card. Afterwards they check together if their approaches match with the learning goal criteria displayed on the respective second diagnostic card. Also the developed self-*diagnostic tool should elicit evidence of student understanding*: If the groups' approach matches with the learning goal, the students get linked to the next diagnostic card. If they have problems or don't know how to continue they can access several GTK-cards for each experimental step. Afterwards they get redirected to the previous diagnostic card. With the information and hints from these GTK-cards they can extend their own knowledge and try to fulfill the task respectively the specific learning goal (otherwise they can choose another GTK-card). The GTK-cards *provide feedback that moves learners forward* as the students get feedback via the diagnostic tool in terms of explanations, examples, hints and definitions. These details are customized for the individual problem and don't contain any solutions. The use of the digital diagnostic tool is voluntary; students can always work on the task without any help. Even if the students can use the tool for every experimental step the texts encourages them to answer the questions on their own. Therefore, this concept is also *activating students as resources for themselve*s.

On the other hand, the concept initiates also *processing and analyzing* to *activate students as resources for each other*: During group work the students can ask group members besides the digital tool. Especially the experiment implementation is designed and posed to be

executed in cooperation. According to this the digital tool is in fact giving hints and explanations but nevertheless the group interaction promotes productivity.

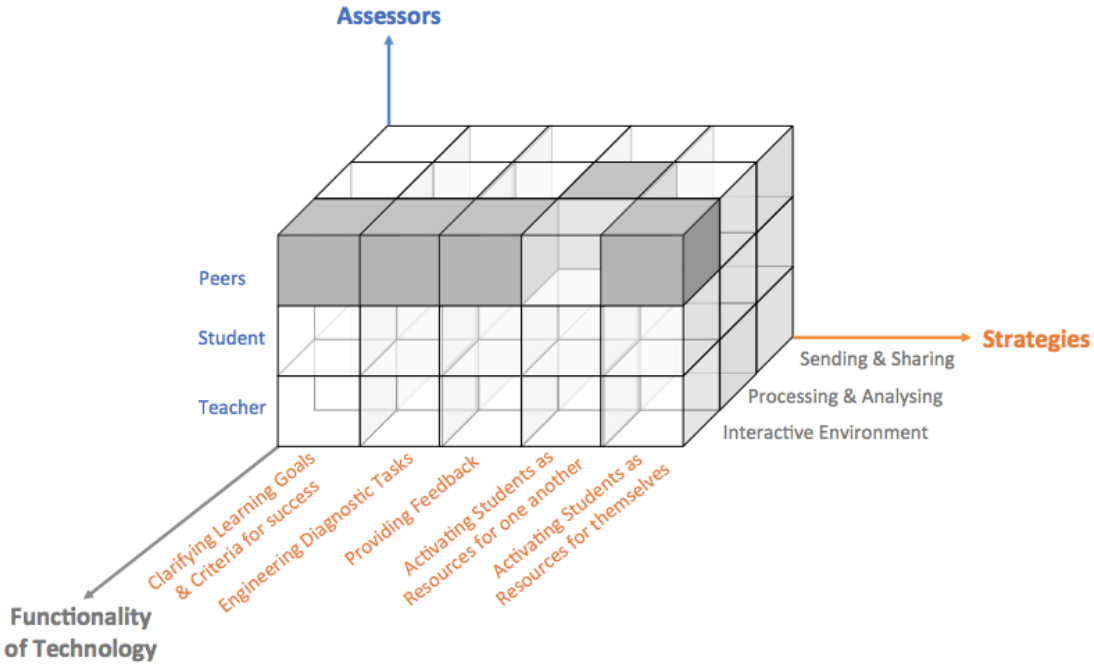

Figure 3: Possible FA strategies used by students working with the digital self-assessment tool functioning as an interactive environment

3. Further Information

3.1 Materials required

Each group needs:

- 2 apples (one variety)
- 1 cutting board
- 1 knife
- 1 stop-watches
- 1 scale
- 2 petri dishes (or saucers, aluminum foil, …)
- 1 hair dryer or drying cabinet

Should also be present:

- Worksheet copy (s. b.)
- Graph paper

3.2 Time needed

The required time depends on the experience (content, methods knowledge) and the composition of the respective students. The experiment can be performed in a two-hour lesson (90 minutes). An additional hour (45 minutes) should be planned for debriefing.

3.3 Using the tool in a classroom discussion

This table gives an overview of possible errors and problems that may occur when working on the task. Each step has got a reference to an appropriate diagnostic card and suggestion on how the teacher can address the problem in a student interview.

Common issues	Self-assessment	Suggested questions and prompts
Experiment		
Student fails to hypothesize For example: Student defines variable wrong Or: limits the hypotheses too much Or: forms unstructured hypotheses	A1	• What do you want to observe in your Experiment? How can you measure it?
	A2	• What can be varied in your experiment? What are the different states of the variable?
	A3	• What is a hypothesis? If I change the variable, what changes can I observe?
Student performs the experiment imprecisely For example: Rounds off the weight inappropriately Or: Fails to subtract the weight of the petri dish	A5	• Use sample data, that the students should compare with their own results →Does the sample data match with your own data? If not, what can be the reason?
		• Do you need to subtract some weight on the scale?
Student fails to establish causality For example: Does not consider the different start weight of the apples Or: Fails to keep the control variables constant	A6	• Can you compare the different test approaches?
		• Do all test approaches have the same conditions? What do you have to keep constant? Are they constant?

Diagramme		
Student chooses an inappropriate diagram type For example: Student chooses a pie chart	A7	• Which type of diagram can represent your information appropriately? •
		• Can this type of diagram be used to display the relation between time and weight?
Student is unable to assign the variables to the axis For example: Student assigns the time to the y-axis and the weight to the x-axis	A8	• Which axis is assigned to which variable?
Student is unable or fails to label the axis (clearly) For example: Student forgets the measurement units or uses indistinct information	A9	• Check if a reader can reconstruct the experiment if only your diagram is available with no additional information. • How can you withdraw from the diagram which units were used to record the data?
Student fails to choose an appropriate scaling For example: Student selects very large/ small intervals between measurement points Or: Uses different sized intervals	A10	• How did you choose the distance between the data points?
		• How does the reader withdraw the intervals of your measurements from the diagram?
		How should the initial and final value of the axes be chosen so that all data fit in this diagram?
Student is unable to plot the data For example: Student wants to maintain a linear or constant diagram form	A11	• How do you create a coordinate system to enter the value pairs of your experiment?
		• How do you plot the data into the diagram?
Student creates a separate diagram for each test approach		• How can you implement the different test approaches in one diagram?
Student fails to draw connecting lines		• In which case may the individual values be connected with lines?

Table 1: Common issues and questions/prompts as well as references to the self-assessment cards/tasks to encounter them

3.4 Alternatives

Teacher assessment

Alternatively, the concept can be used in a lesson with teacher diagnosis, the teacher acts as a consultant when problems arise. He diagnoses potential problems and stimulates the learning process during the working phase in group, partner or individual work. These suggestions for questions and prompts which the teacher can use to help with individual problems and issues, can be found in table 1.

Pen-and-paper version of the tool

The pen-and-version of the tool is an alternative to the digital version when the required software and devices cannot be provided. The cards are structured in the same way as the digital tool. In comparison to the digital tool, the pen-and-paper version provides hyperlinks by giving references to the following card.

4. Materials to Download / Glossary

- Worksheet for use in classroom
- Template of the experimental protocol
- Diagnosis cards
- “Good to know” cards