FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Sweet or sour? Teeth don't like either. – Planning and performing an experiment about the acid-protective effect of toothpaste

Subject:	Science
Age of students:	14 - 16 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 plan and perform an experiment about the acid-protective effect of toothpaste.

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Open-Minded

1. Content

This lesson unit deals with an experiment about the acid-protective effect of toothpaste. The students examine the effect of acid on calcium-containing compounds in a student-related context. They propose independently a suitable problem and an appropriate scientific hypothesis to the given text which should be tested in the designed experiment.

2. Activity

2.1 Aims

Scientific Goal

The Students can conclude that the calcium layer of the chicken eggs (also called lime) is attacked by the acetic acid and dissolves with the formation of CO_2. The treatment of the calcium layer with fluoride toothpaste slows down the decomposition of calcium. Even after washing off the toothpaste the protective effect is partly existing. The drawn conclusion can then be transferred back to the function of the toothpaste when applied to teeth: The toothpaste protects the tooth surface (calcium compounds) when it comes in contact with acidic foods.

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 qualitative 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

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

2.2 Possible applications in the classroom

The material can be used in 8th grades with pupils who are 14 to 16 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.

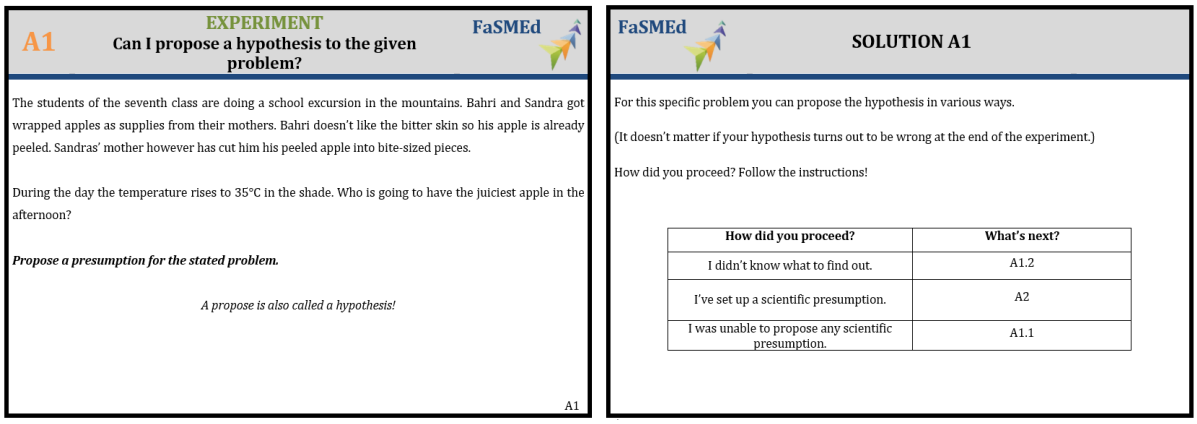
If the students work on their tasks using **self-diagnosis** tools, they will be offered a variety of context-sensitive aid cards („Good to know" cards), which help with individual difficulties or problems and provide further information. Therefore, the students have to diagnose their own difficulties 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

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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 illustrates 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.

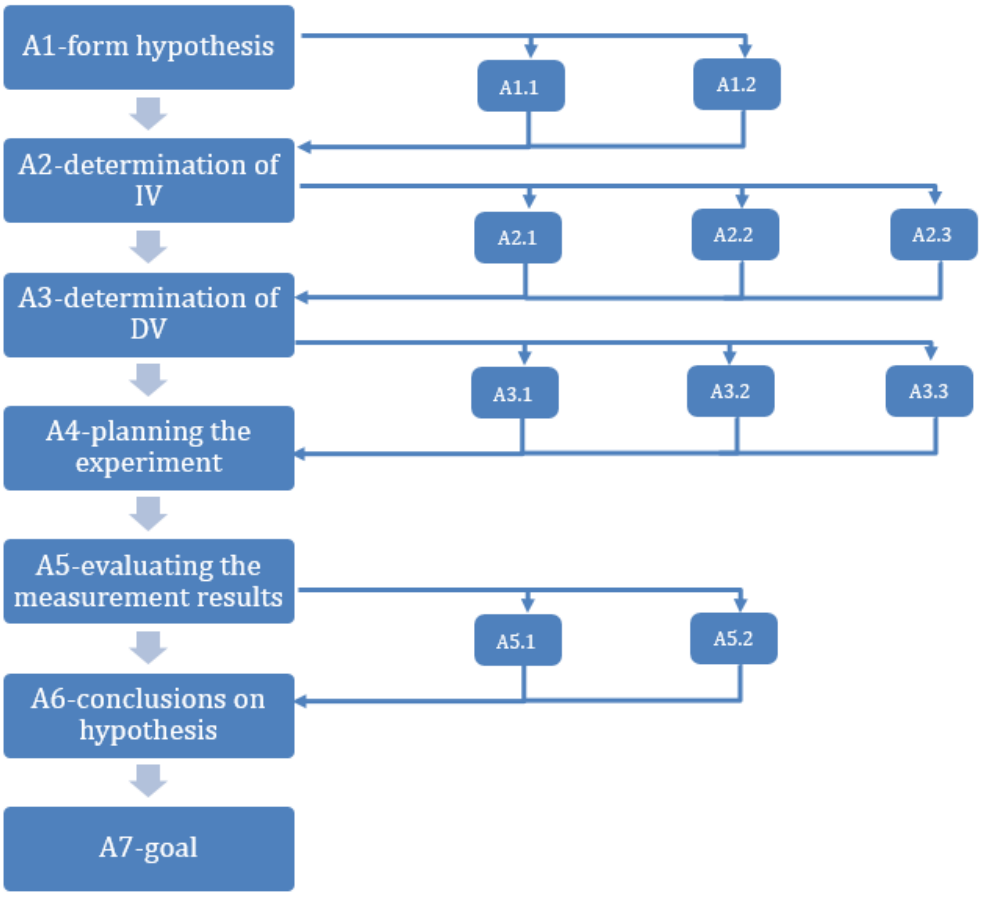

Figure 2: Structure of the disgnostic and "Good to know" cards

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 devel-

oped 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 themselves*.

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.

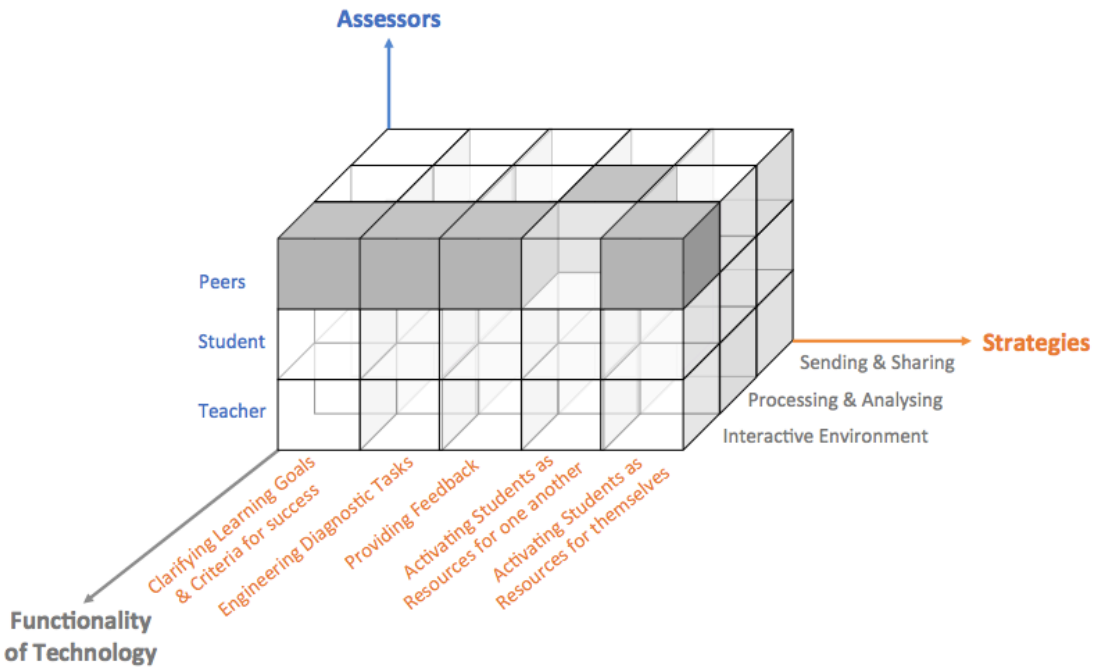

Figure 3: Possible FA strategies used by students working with the digital self-assessment tool functioning as an interactive environment

3. Further Information

3.1 Materials required

Equipment:

- A beaker
- Protective gloves
- Goggles
- Paper towels

Chemicals:

- Vinegar
- Fluoride toothpaste
- Water
- Hard-boiled egg

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?

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