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Science, technology, and values guideline

Methods for implementing the value aspects in science and technology lessons with Experimento I 8+

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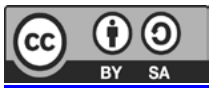

As a non-profit corporate foundation, we promote sustainable social development, which is crucially dependent on access to basic services, high-quality education, and an understanding of culture. To this effect, our project work supports people in taking the initiative to responsibly address current challenges. Together with partners, we develop and implement solutions and programs to support this effort, with technological and social innovation playing a central role. Our actions are impact-oriented and conducted in a transparent manner.

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Foreword

A sense of responsibility, the ability to reason, and independence: These are essential traits for being able to resolutely orient one's self in today's pluralistic, complex world and make confident decisions. Successful development of these competencies requires the teaching of values at an early stage. Values form benchmarks, create criteria, and strengthen our personal and cultural identity: They guide and support our individual and professional development.

In addition to the family environment as a place for value formation, schools in particular also have a role to play here as a component of their educational responsibility. The development of the ability to make ethical decisions and the strengthening of an independent and socially competent personality are primary elements of value formation through the schools. Science and technology lessons play an important role as an experimentation space for the examination of values. The work with scientific and technical issues requires evaluation, decisions, and reflection. At the same time, it promotes attitudes, competencies, and approaches that empower people to live responsibly and self-confidently in modern society.

With its international educational program called Experimento, the Siemens Stiftung aims to strengthen the teaching and formation of values during science and technology lessons. Experimento is built on the principle of research-based learning, a method that fosters empathy and self-confidence and sensitizes students to social interaction through cooperative experimentation. These are valuable characteristics in terms of successful personality development and are an excellent foundation for the formation of values.

With this in mind, we worked with the Psychology Department at the Ludwig Maximilians University of Munich to refine the Experimento | 8+ module through targeted implementation of the value aspects and prepare it for use in elementary school lessons. Values are formed on the one hand through selected "values related to the learning process" such as openness, acceptance of responsibility, and team spirit. So-called "object-related values" such as solidarity, environmental awareness, and sustainability are related to the content dimension of the Energy, Environment, and Health modules covered in Experimento | 8+. Teachers thus have the opportunity to link scientific and technical learning on future-relevant topics with issues related to the development of individual value competencies.

We are pleased that you are involved in this valuable teaching and learning method. This guideline is designed to provide you with helpful suggestions for how to integrate value formation into science and technology lessons.

We look forward to working with you and wish you much success in "forming values."

Dr. Barbara Filtzinger
Head of Working Area Education, Siemens Stiftung

Science, technology, and values guideline

Contents

1 What is the purpose of this guideline?

This guideline is designed to support teachers interested in using the work with Experimento l 8+ for successful value formation in science and technology lessons.

Experimento l 8+ provides a sound basis for confronting students during science and technology lessons with value-related issues beyond the curricular content. This guideline shows how values can be integrated into Experimento lessons and which goals can be targeted. In addition, it presents methodical-didactical approaches to promote the discussion of values during science and technology lessons.

The guideline first establishes a reference between values and the experiments in Experimento l 8+. In particular, it also considers the question of why the formation of values is important within the context of science and technology lessons. The values selected, with input from experts, are listed below. The values can be related to the activities in the learning process of the experiment and to the object of the experiment. An overview of the possibilities for integrating the values in science and technology lessons within the context of Experimento l 8+ is provided at the end. Various methods are presented to facilitate sensitization for values.

2 Why is the topic of science and technology important in connection with values?

There is a growing need to communicate about issues related to values. This is a challenging development task both for individuals and for society. Values are conscious or subconscious orientation standards and general principles of individuals and society. People around the world have values, but they vary culturally, individually, or among specific groups. Common values can unite people, while different values sometimes make value-based behavior more difficult.

For example, different values can come into play in complex everyday situations. However, inconsistencies in behavior may also arise due to diverging interests of various individuals and segments of society. This may lead to a gap between knowledge about values and actual value-based behavior.

Due to the importance of values in personal and social life, it is necessary to encourage a heightened awareness of values early on. Values decisively influence our thinking, behavior, and interaction with each other and play a major role in science and technology lessons. In this context, the topic of values should be addressed in connection with scientific and technical issues as part of Experimento I 8+.

Why are values so important in science and technology lessons? Science and technology are often viewed as the engine of societal revitalization and progress. Children and young people are already confronted with scientific-technical problems. However, working solely with corresponding issues in science and technology lessons is not sufficient for an assessment of the importance of such topics. Values support science and technology lessons in the following aspects:

- Assessing issues and making decisions
- Understanding different issues and being able to see things from different perspectives
- Reflecting on and evaluating issues related to science and technology
- Enabling participation in society

Linking science and technology with value formation requires that values be considered when teaching science and technology. This guideline provides practical tips on the methodical-didactical approach for Experimento I 8+.

3 What values are addressed in Experimento l 8+?

A number of values appear to be suitable for science and technology lessons. With input from experts, the Siemens Stiftung selected the following values for Experimento l 8+: openness, initiative, acceptance of responsibility, team spirit, tolerance, dependability, solidarity, environmental awareness, and sustainability.

The values should be discussed based on the specific experiment. The values can be related to the learning process (1) and the object (2). While it is primarily the values that are significant as fundamental values during the experimentation phase that are addressed in the learning process, object-related values are directly related to the experiment's topic.

(1) **Values related to the learning process** are addressed during experimentation.
Values play a fundamental role in interaction with each other and also in independent behavior. "Values related to the learning process" include openness, initiative, acceptance of responsibility, team spirit, tolerance, and dependability. One example of implementation of the value "team spirit" is that mutual support is provided during the cooperative experimentation phase.

(2) **Object-related values** refer to the content dimension of the Energy, Environment, and Health modules discussed in Experimento l 8+. "Object-related values" include openness, initiative, acceptance of responsibility, solidarity, environmental awareness, and sustainability.
An example of implementation of the value of "acceptance of responsibility" means that actions are taken to handle the environment responsibly – for example, by separating waste.

The values of openness, initiative, and acceptance of responsibility relate to the learning process as well as to the object. For example, the value of *openness* means being receptive to new things. Thus, *openness* is addressed as a value related to the learning process in the context of group work if the point is to discover new information during the experiment. Related to the object, *openness* means being receptive to scientific phenomena.

The following sections provide tips and suggestions for planning teaching and learning units to help conduct the experiments while integrating the value reference. Examples are used to explain the values and their importance as well as their implementation in science and technology lessons.

(1) Values related to the learning process

Values related to the learning process are addressed during experimentation. Values play a fundamental role, both in interaction with each other and in independent behavior.

The following breakdown illuminates individual values and their importance while also highlighting examples of possible implementation in science and technology lessons.

The value and its importance	Example of implementation in science and technology lessons
Openness … means being receptive to new things.	▪ Wanting to discover new things ▪ Asking questions ▪ Scrutinizing topics, results, and one's own position ▪ Making, admitting, and reflecting on mistakes
Initiative ... means becoming active on one's own.	▪ Developing one's own solutions and paths ▪ Formulating and pursuing objectives ▪ Making decisions independently and acting independently ▪ Striving for knowledge and new insights
Acceptance of responsibility … means bearing the consequences for one's own decisions and behavior.	▪ Conducting an experiment responsibly ▪ Handling materials responsibly ▪ Taking on responsibility for the preparation, execution, and results of an experiment
Team spirit … means cooperating effectively and successfully.	▪ Making one's best contribution to a solution ▪ Providing mutual support while conducting the experiment ▪ Offering to help others and approaching them ▪ Listening to others without interrupting them
Tolerance … means recognizing different opinions.	▪ Listening to all opinions (including those different from one's own) ▪ Accepting other opinions ▪ Constructively discussing and evaluating solutions ▪ Accepting different learning speeds and levels
Dependability … means keeping binding agreements.	▪ Being able to rely on one another ▪ Precisely following specified instructions, performing tasks punctually ▪ Obeying established rules and agreements ▪ Cleaning up materials and disposing of them in an environmentally compatible manner

(2) Object-related values

Object-related values refer to the content dimension of the Energy, Environment, and Health modules discussed in Experimento l 8+.

Since object-related values always include a content dimension, they are presented in the context of the respective subtopic. Their meaning and examples are also provided.

Energy module

In this module, students become familiar with the basic phenomena of electric current and should also understand the concept of a circuit. The materials for Experimento l 8+ encourage students to explore the processes of conversion of electrical energy and to learn further about the importance of energy in the natural and technical worlds.

The value and its importance	Sample implementation in the Energy module
Openness … means being receptive to new things.	▪ Being receptive to discovering scientific phenomena in the area of energy.
Initiative ... means becoming active on one's own.	▪ Developing one's own ideas and solutions for using electricity.
Acceptance of responsibility … means bearing the consequences for one's own decisions and behavior.	▪ Thinking about how various resources can be conserved.
Solidarity … means understanding cohesion and mutual support in society.	▪ The value of solidarity is covered as a main point in the *Environment module*.
Environmental awareness … means protecting the environment and behaving in an environmentally sensitive manner.	▪ Behaving in an environmentally sensitive manner by saving electricity.
Sustainability …means also being considerate of the people and animals of other countries.	▪ The value of sustainability is covered as a main point in the *Environment module*.

Environment module

In the Environment module, students are made aware of how they can make a contribution to preserving the environment. The focus here is on the water cycle, water purification, air pollution, recycling, and renewable energies. For instance, students should understand the importance of waste separation and develop options for taking action to protect the environment.

The value and its importance	Sample implementation in the Environment module
Openness … means being receptive to new things.	▪ Going through life with open eyes. ▪ Becoming sensitized to the local environment.
Initiative ... means becoming active on one's own.	▪ Actively discovering and investigating the environment.
Acceptance of responsibility … means bearing the consequences for one's own decisions and behavior.	▪ Taking actions to protect the environment and standing by them.
Solidarity … means understanding cohesion and mutual support in society.	▪ Becoming aware of the fact that everyone can make a contribution to a well-functioning environment. ▪ Showing consideration for other segments of society.
Environmental awareness … means protecting the environment and behaving in an environmentally sensitive manner.	▪ Becoming aware of the importance of the natural environment and its preservation. ▪ Having a connection with the natural environment and taking possible actions.
Sustainability ... means also being considerate of the people and animals of other countries.	▪ Recognizing that the topic of the environment goes beyond national borders. ▪ Becoming aware of the increasing scarcity of energy resources as a global problem.

Health module

In the Health module, students become aware of their own bodies and develop an awareness of healthy nutrition and its importance in their lives. The focus here is on the topics of nutrients, hygiene, sense of hearing, sense of vision, respiration, and muscles and bones. For instance, the students should understand why nutrients are vital for humans and how they can do something for their own health by eating a healthy diet.

The value and its importance	Sample implementation in the Health module
Openness … means being receptive to new things.	▪ Being receptive to getting to know one's body and its functions.
Initiative ... means becoming active on one's own.	▪ Playing an active role in maintaining the health of one's own body.
Acceptance of responsibility … means bearing the consequences for one's own decisions and behavior.	▪ Becoming aware that it is important to take good care of one's own body.
Solidarity … means understanding cohesion and mutual support in society.	▪ The value of solidarity is covered as a main point in the *Environment module*.
Environmental awareness … means protecting the environment and behaving in an environmentally sensitive manner.	▪ The value of environmental awareness is covered as a main point in the *Environment module*.
Sustainability ... means also being considerate of the people and animals of other countries.	▪ The value of sustainability is covered as a main point in the *Environment module*.

4 How are values integrated into Experimento l 8+?

Experimento l 8+ includes experimentation instructions for students between 8 and 12 years of age and their elementary school teachers. With the help of these teaching and learning materials, teachers are trained to augment science and technology lessons with cooperatively conducted experiments to encourage the formation of values. In this way, students should better understand correlations between the scientific or technical phenomenon and its associated value. The student instructions are designed such that the students should be able to easily consult the instructions and perform the experiments on their own.

The experimentation instructions are organized using various easily recognizable symbols. Accordingly, these symbols are also found in the teacher instructions. They offer clarity as a central concept of Experimento l 8+. The symbols in the student instructions represent specific actions to be taken; the teacher instructions include more in-depth information at each of these symbols. The following symbol (compass) is used to integrate the reference to values into Experimento l 8+:

The conceptual approach of the experiments in Experimento l 8+ is important so that the values can be integrated into the experiments. This approach is based on three didactic methods: research-based learning, cooperative learning, and problem-oriented learning. The didactic concept of Experimento l 8+ focuses on the activity, self-monitoring, and cooperation of the students in all topics. They support the integration of the value aspect into Experimento l 8+ and encourage the students' thinking processes for values.

Specific methodological components put the didactic focus on the values. Thus, in line with the dominant educational themes of the experiments in the Energy, Environment, and Health modules, teaching suggestions for promoting the values in science and technology lessons are described below.

The following methods can be selected for practical lesson planning:

- **Techniques to get the students thinking**
- **Use of cases with dilemmas**

Teachers can use these methods flexibly in Experimento l 8+ to encourage discussions of values.

Teachers can choose a method depending on the selected experiment and the students' prior knowledge. In this way, the students and teacher can shape the learning process together. The student instructions provide teachers with the opportunity to introduce a topic and simultaneously support the students during the experimentation phase. The flexible integration of the method for value aspects into the student instructions allows teachers to illuminate the value aspect of scientific and technical issues more precisely through prompts or cases with dilemmas. The objective of all methods is to stimulate discussion and reflection on value-related behavior.

The following instructions apply to both methods:

1. Methodically **prepare** the starting point for the discussion of values (see 4.1 and 4.2: techniques to get the students thinking or dilemmas).
   For example, you can read the text of the dilemma or the statements for discussion to the class or write a question for discussion on the board. Alternatively, you can hand out the work instructions so that the students initially experience the text/prompt quietly at their desks or in partner work.

2. **Discuss** the starting problem with the students.
   For example, you can discuss why a light should not be left on all day (A1.1), why it is important to carefully separate waste (such as paper) (B5.2), or why it is important to eat a healthy diet (C1.1).

   Tip: Before the discussion with the entire class, you can have the students think about the problem in partner work or group work.

   If necessary, encourage the students by using **questions for discussion** (as "help prompts"), such as:
   - "What do you think about that?"
   - "Why do you think that is so?"
   - "Do you think that is okay?"

3. **Clarify** various **positions** and value-based **opinions**.
   Incorporate the addressed values. Allow the students to find reasons for these positions and opinions.

4. **Record** the students' positions and opinions.
   For instance, write the different opinions and views on the board.

5. Hold a **closing class discussion**.
   Above all, clarify the question: *What is the "takeaway" for the students?*
   You and the students can also develop possible actions for everyday life.

6. **Reinforce** the **results**.
   Have the students record the various results in writing; for example, as an entry in their exercise books.

The basic aspects of the two methods, as well as practical examples of values related to the learning process and object-related values in the three Energy, Environment, and Health modules, are presented below.

4.1 Techniques to encourage students to reflect in Experimento I 8+

Techniques to get the students thinking can be verbal (for example, observations, requests) or nonverbal (for example, pictures, gestures). Their purpose is to encourage the students to reflect. Through a prompt on a certain topic or problem, the students are motivated to express opinions, thus creating opportunities for discussion. For this purpose, both the topic and the material must be understandable. Value-related prompts are suitable for quick integration into science and technology lessons. Subconscious views, opinions, or attitudes on value-related topics may be brought to light during the process.

A prompt through observations, requests, or questions is essential for the method. Other prompts can be used as well, such as pictures, cartoons, video clips, songs, newspaper articles, quotations, or gestures.

Prompts as starting point for the discussion based on reflections

The prompts serve as a starting point for the actual discussion in order to support constructive handling of technical, personal, social, and societal aspects.

Depending on the extent to which a reflections-based discussion takes place – for example, through the use of images for discussion – a direct discussion question (such as “Is it good or bad that trees are cut down?”) can support the students in developing a dialog that illuminates the value-related problem.

The instructions for conducting the discussion are found on page 14.

In the following sections, you will find examples of prompts for values related to the learning process and examples of prompts for object-related values.

4.1.1 Examples of values related to the learning process

Starting point: The students have conducted the experiments.

Purpose of reflection: The students should reflect on what went well and what didn't go well when they worked in the group. The value of *team spirit* (reviewing/optimizing work together as a team) is addressed in the process. However, the value of *dependability* (complying with rules) may come up.

Examples of prompts:

Questions for discussion: *How did working together in your group go?*
Did you follow the instructions?

Statement for discussion: Observation by the teacher:
"I observed that some groups did not work well together."

The following possible statements by the students are listed here as examples to provide teachers with assistance for the reflection. The students may make other statements based on the prompt.

Possible examples of students' statements:

What goes well in group work?	What doesn't go well in group work?
▪ Working together is fun. ▪ A lot of ideas come up.	▪ I am faster by myself. ▪ One person does all the work.

4.1.2 Examples of object-related values

Various prompts for examining object-related values based on the Energy, Environment, and Health modules are listed here.

Energy – A1 Simple electric circuit, subexperiment A1.1 “The lamp should light up!”

Starting point:	In the experiment, the students have examined the topic of current.	
Purpose of reflection:	The students will consider why it is important to save electricity. In addition, they will collect ideas on how they themselves can save electricity. The value of *acceptance of responsibility* (conscious use of energy) will be addressed in the process. However, the value of *initiative* (taking active measures to save electricity) may also be addressed.	
Examples of prompts:	**Question for discussion:**	Think about the situations when you turn on the light. *When do you really need the light and when could you manage without it?*
	Statement for discussion:	Observation by the teacher: *“A student told me that he forgot to turn the light off again today when he went to school.”*

Environment – B5 Recycling, subexperiment B5.2 “Making new from old: Making paper”

Starting point: In the experiment, the students have examined the origin of recycled paper.

Purpose of reflection: The students will consider the sensible use of paper. The value of *environmental awareness* (conscious use of scrap paper, waste separation) will be addressed in the process. However, the value of *initiative* (taking active measures to save paper) may also be addressed.

Examples of prompts:

Image for discussion:

Question for discussion: *What can you do to save paper or to use paper multiple times (for example, at home, at school*)?

Health – C1 Nutrients , subexperiment C1.3 “Fat detectives”

Starting point: In the experiment, the students have examined the topic of fats in foods.

Purpose of reflection: The students will collect examples of healthy and unhealthy foods or of healthy and unhealthy fats and think about what they should be mindful of in their nutrition.
The value of *acceptance of responsibility* (taking care of one’s own health) will be addressed in the process.

Examples of prompts:

Image for discussion:

Question for discussion: *Why is it important that you do not eat a bag of chips every day?*

4.2 Use of cases with dilemmas in Experimento I 8+

The use of cases with dilemmas helps create an awareness of a value-related conflict. Students reflect on the fact that a decision has certain consequences. Through controversial discussion of dilemmas related to values, the students reflect on values and become acquainted with various positions and perspectives.

Discussion of a dilemma based on a particular story is essential for this method. This story can be read aloud by the teacher, worked on in groups, and finally discussed. In addition, role-playing dilemmas can be carried out and contemplated. The various roles are assigned and acted out.

In the following sections, you will find examples of cases with dilemmas for values related to the learning process and examples of cases with dilemmas for object-related values.

4.2.1 Example of values related to the learning process

Dilemma related to working in a group:

Paul is very shy. Frank and Frida have to conduct an experiment in a group with Paul. Frank and Frida are not thrilled about it and proceed to conduct the experiment by themselves. Paul would like to help and quietly gives them tips. However, the other two do not listen to him. As the teacher checks on the group, she says, “Are you sure that your experiment is working? You’re missing water, aren’t you?” Paul thinks to himself, “That’s what I told them.”

Think about it: Should Paul say something or remain quiet?

Addressed value:

Team spirit (listening to each other)

4.2.2 Examples of object-related values

Energy – A1 Simple electric circuit, subexperiment A1.1 “The lamp should light up!”

Dilemma related to a sister and the light:

Hugo frequently quarrels with his older sister. She thinks she always knows better only because she is older. Hugo’s sister is often the last one in the bathroom in the morning and frequently leaves the light on. Their mother has often told her that she shouldn’t do that because it is important to save electricity. As Hugo is walking to the bus to ride to school, he sees that the light in the bathroom is still on.

Think about it: What would you do in Hugo’s place?

Addressed value:

Dependability (obeying established rules and agreements)

Environment – B5 Recycling, subexperiment B5.2 “Making new from old: Making paper”

Dilemma related to grandmother’s trash:

You spend many afternoons at your grandmother’s house. You really like her. She frequently sits in her armchair because she can no longer get around very well. One day she tells you that she finds it bothersome to have to neatly gather her scrap paper and toss it in the designated recycling bin. She finds it much easier to throw her wastepaper in the normal trash bin instead of using the scrap paper bin. She says it’s much more practical and, besides, your grandmother always did that in the past.

Think about it: What do you think about your grandmother’s behavior?

Addressed value:

Environmental awareness (treating the environment carefully)

Health – C1 Nutrients, subexperiment C1.3 “Fat detectives”

Dilemma related to chips:

In the afternoons you go to the supermarket with your friend to buy something with your allowance. Your friend picks up a bag of chips off the shelf and tries to convince you that you should pool your money to buy the chips. He/she doesn’t have enough money to buy the chips because they are too expensive. Your friend is very important to you and you would like to help.

Think about it: How would you behave?

Addressed value:

Acceptance of responsibility (being responsible for one’s own health)

4.3 Example of methodological implementation in Experimento I 8+

In this section, you will find an example from the teacher instructions for the Health module, topic of nutrients, subexperiment C1.3 “Fat detectives.”

In the discussion about values for this experiment, the teacher can provide a prompt or tell a story that poses a dilemma. What’s important is that the reference to values can be established in the experiment. The values to be discussed can be either those related to the learning process (for example, “Was the group work team-oriented?”) or object-related values (for example, “Why is it important that you do not eat a bag of chips every day?”). The student instructions for C1.3 “Fat detectives” address object-related values. The students may need support, but the following methods should help them examine the values in this experiment.

Object-related dilemma: An object-related dilemma can be integrated in the discussion of the value “acceptance of responsibility” (being responsible for one’s own health) at the end of the student instructions. The students should express their opinions.

Dilemma related to chips:

In the afternoon you go to the supermarket with your friend to buy something with your allowance. Your friend picks up a bag of chips off the shelf and tries to convince you that you should pool your money to buy the chips. He/she doesn’t have enough money to buy the chips because they are too expensive. Your friend is very important to you and you would like to help.

Think about it: How would you behave? What do you think about your friend’s behavior?

Questions, if necessary: Encourage the students, if necessary, using questions for discussion, such as:
- “What do you think about that?”
- “Why do you think that is so?”
- “Do you think that is okay?”

Possible examples of students’ statements:

Do not listen to my friend	**Listen to my friend**
▪ Fat can be unhealthy ▪ I would rather buy something else	▪ Chips taste good ▪ Help my friend ▪ It’s my own money

Objective: The students should learn to pay attention to their own bodies.
This dilemma deals with the value of acceptance of responsibility (being responsible for one’s own health).

Alternatives: Prompts can also be used to lead to the case with a dilemma formulated in the student instructions or for the following reflection. The value of acceptance of responsibility (being responsible for one’s own health) remains unchanged.

- Image for discussion shown by the teacher: A picture of chips.
- Question for discussion (necessary only if a discussion did not ensue from other prompts): Why is it important that you do not eat a bag of chips every day?

Note: The students should reflect on values and express their opinions. It may turn out that several values are addressed, such as initiative.

In collaboration with the Ludwig Maximilians University of Munich, Psychology Department