THE NATURE OF ENVIROMENTAL SOCIO-SCIENTIFIC ISSUES

How do they look like and why are they relevant for STEM teaching

Structure of session

1. What are environmental socio-scientific issues?
    1. Two introductinal examples
    2. Definition of environmental SSI
    3. How to deal with enviromental SSI?
2. How do environmental socio-scientific issues connect to mathematics and science education?
    1. Reflection on the aims of mathematics and science education
    2. Linking SSI to key competence framework
    3. What does citizenship education mean for maths and science?
    4. Reflecting on possibilities and limitations of maths and science
3. How to include environmental socio-scientific issues into teaching?
    1. Example tasks for secondary level – what do students learn?
    2. Designing a lesson

1. What are environmental socio-scientific issues?

Example 1: Should wind power plants be set up everywhere?

Wind turbines are generally considered a clean energy source. Nevertheless, the construction of wind turbines, especially near residential areas, divides our society.

Example 2: Should the SARS-Covid-2 vaccination be obligatory?

For many diseases, vaccinations provide effective protection, but always carry certain risks of vaccine reactions. Whether vaccinations should be used or not is therefore always a weighing of the risks and often leads to differing opinions both in society and among experts.

Activity 1.1:a) “Should wind power plants be set up everywhere”

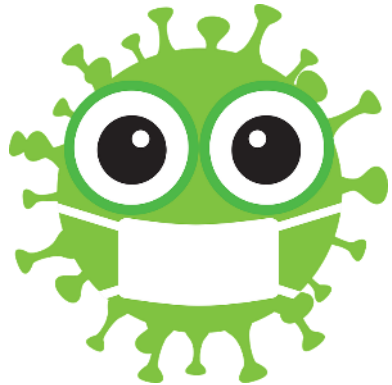
The goal of this task is to show how different opinions evolve and strengthen.

1. Would you accept a wind power plant near your house?
   - What are the advantages/disadvantages of installing wind power plants?
2. Put yourself in the role of a politician/expert. How would you argue…
   - … if you would like to promote the installation of a wind power plant close to your village
   - … if you oppose installing wind power plants in your village
3. Do a research.
   - Find list of (seemingly) scientific based arguments favoring respectively opposing the use of wind power plants.
   - Elaborate on the connection between the main question and scientific facts.
   - What other aspects influence the decision on setting up wind power plants?

Activity 1.1b): Should the SARS-Covid-2 vaccination be obligatory?

The goal of this task is to show how different opinions evolve and strengthen.

1. Are you for or against *SARS-Covid-2* vaccination?
   - How do proponents argue?
   - How do opponents of vaccination argue?
2. Put yourself in the role of an expert/politician. How would you argue…
   - … if you would like to promote a vaccine mandate for SARS-Covid-2
   - … if you oppose installing a vaccine mandate for measles
3. Do a research.
   - Find list of (seemingly) scientific based arguments favoring respectively opposing the use of vaccines.
   - Elaborate on the connection between the main question and scientific facts.
   - What other aspects influence the decision on vaccination?



Activity 1.2: Should wind power plants be set up everywhere?/Should vaccination be mandatory -> choose your example

1. In how far is it important to reflect on such questions?
2. Which topics are normally dealt with in relation with these examples at school?
3. To what extend do these topics prepare students in dealing with such questions.
4. What questions or facts do you miss?
5. Conclude: Would you use this example in class? If yes, what should students learn from?

Socio-scientific Issues (SSI)

- Such problems as the wind power question and the vaccination question are examples of **Socio-scientific Issues (SSI's)**.
- SSIs have a basis in science and require people to engage in dialogue, discussion, and debate.
- They are mainly controversial in nature.
- They require forming opinions and making decisions including moral, ethical or social reasoning issues.

Socio-Scientific Issues (SSI)

Intransparent or incomplete information situation:

- Mostly, people have to deal with these issues through incomplete information because of conflicting or incomplete scientific evidence and incomplete reporting

Lack of objectivity

- Often these issues involve a cost-benefit analysis in which risk interacts with ethical reasoning

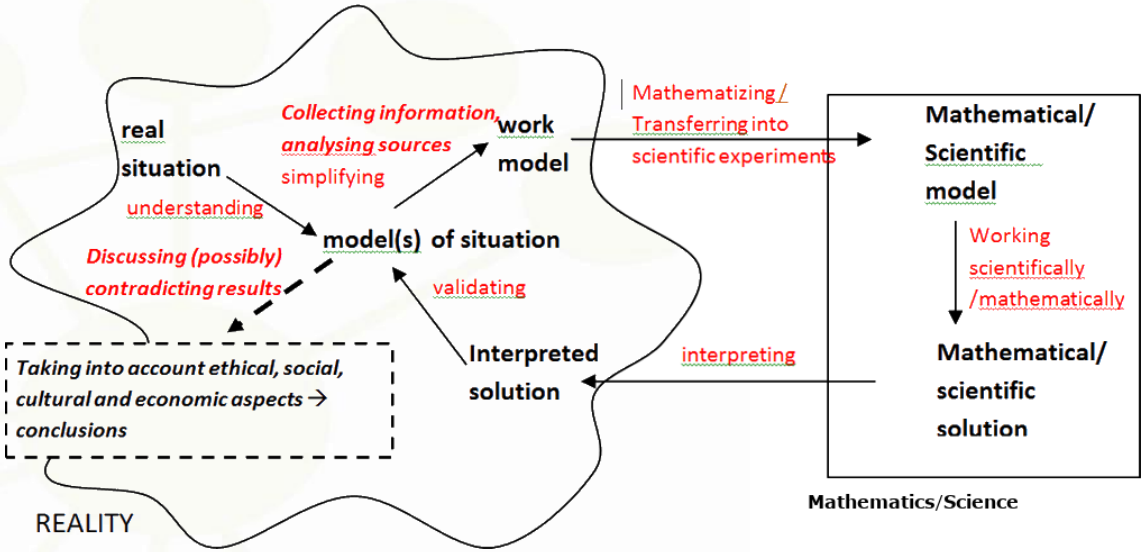
Activity 1.4: How to proceed when dealing with SSI?

Should wind power plants be set up everywhere?

Should the SARS-Covid-2 vaccination be obligatory?

How do we have to proceed when dealing with a socio-scientific issue in class?
What has to be taken care of specifically?
Set up a list of steps that need to be taken.

Dealing with Socio-Scientific issues



From Maass, Doorman, Jonker, Wijers (2019).

2. How do environmental SSI connect to mathematics and science education?

Activity 2.1: What are the aims of mathematics and science education?

- What are the objectives of mathematics & science education from your perspective?

- What do students learn when dealing with tasks like example 1 and example 2?

Key Competence Framework of the EU

COM (2019). Key competences for lifelong learning

Mathematical competence

Mathematical competence is the ability to develop and *apply mathematical thinking and insight in order to solve a range of problems in everyday situations*.

Mathematical competence involves the ability and willingness to use mathematical modes of thought and presentation (formulas, models, constructs, graphs, charts).

(COM, 2019)

Mathematical competence: Knowledge, skills and attitudes

Skills:

- An individual should have the skills
  - to apply basic mathematical principles and processes *in everyday contexts* at home and work (e.g. financial skills),
  - and to follow and assess chains of arguments.
- An individual should be able
  - *to reason mathematically*, understand mathematical proof and communicate in mathematical language,
  - to use appropriate aids including statistical data and graphs and understand the mathematical aspects of digitalization.

Competence in Science: Knowledge, Skills and Attitudes

Competence in science refers to…

- The ability and willingness to *explain the natural world* by making use of
  - knowledge and methodology
  - observation and experimentation.
- The ability to identify questions and to draw evidence-based conclusions.
- The *understanding of the changes caused by human activity and responsibility* as an individual citizen.

Competence in Science: Knowledge, Skills and Attitudes

Skills include

- the understanding of science as a process for the investigation through specific methodologies, including observations and controlled experiments,
- the ability to use logical and rational thought to verify a hypothesis and the readiness to discard one's own convictions when they contradict new experimental findings.
- the ability to use and handle technological tools and machines as well as scientific data to achieve a goal or to reach an evidence-based decision or conclusion.
- the ability to recognize the essential features of scientific inquiry
- the ability to communicate the conclusions and reasoning that led to them.

Source: (COM, 2019)

Citizenship Competence

Citizenship competence is the ability

- to act as responsible citizens and to
- *to fully participate in civic and social life, based on understanding of social, economic, legal and political concepts and structures, as well as global developments and sustainability.*

Citizenship Competence

- Skills for citizenship competence relate to the ability to engage effectively with others in common or public interest, including the *sustainable development of society*.
- This involves *critical thinking and integrated problem solving skills*, as well as skills to develop arguments and constructive participation in community activities, as well as *in decision-making at all levels*, from local and national to the European and International level.
- This also involves the ability to access, have a critical understanding of, and interact with both traditional and new forms of media and understand the role and functions of media in democratic societies.

Activity 2.2: What does citizenship education mean in relation to science and mathematics education?

- What could citizenship education in relation to science and mathematics mean?
- Is something like citizenship competence included in the syllabus? If so: Where and how?

Activity 2.3: What are possibilities and limitations of maths and science?

- What can mathematics and science offer to find solutions to global challenges?
- What can mathematics and science not offer to solve global challenges?

Activity 2.3: What are possibilities and limitations of science?

Consider the following list of myths about mathematics and science.

- How do they reflect reality?
- If you consider them to be wrong, correct them.

We will later discuss your ideas jointly.

Myths
Hypotheses become theories which in turn become laws.
Scientific laws and other such ideas are absolute.
A hypothesis is an educated guess.
A general and universal scientific method exists.
Evidence accumulated carefully will result in sure knowledge.
Science and its methods provide absolute proof.
Science is procedural more than creative.

Objective: Fighting against myth about science

Consider the following list of myths about science. How do they reflect reality? We will later jointly discuss your thoughts.

Myths
Science and its methods can answer all questions.
Scientists are particularly objective.
Experiments are the principal route to scientific knowledge.
Scientific conclusions are reviewed for accuracy.
Acceptance of new scientific knowledge is straightforward.
Scientific models represent reality.
Science is a solitary pursuit.
Science and technology are identical.

Maths and Science education

Should maths and science education give students insight into possibilities and limitations of maths and science and clarify myths?

- If so, how?
- If not, why?
- How can dealing with environmental SSI contribute to this?

3. How to include environmental SSI into teaching?

Activity 3.1: What do students learn when dealing with SSI?

This is an exemplary task for students, solve the exercise yourself.

Everywhere in Europe people try to avoid junk mail in their mailbox by using “NO JUNK MAIL” stickers. However, often people do not use such stickers on throw any advertisement directly in the trashcan. This produces unnecessary waste of paper. In Amsterdam it is now forbidden to put junk mail in the mailbox as long as it is not explicitly allowed with a special sticker. The city reported, since then the paper waste decreased significantly.

How would such a ruling affect your city? Discuss how much paper waste could be avoided and which other effects (i.e. economical) may play a role?

Activity 3.1: What do students learn when dealing with SSI?

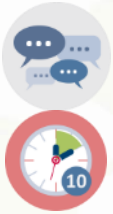
This is an exemplary task for students, solve the exercise yourself.

While discussions about climate change are heating up and divide our country, electric cars become more and more popular throughout our society.

Critics of electric cars often argue that the need for rare earth elements in batteries makes their life cycle assessment (LCA) worse than the LCA of Diesel cars.

Do you think an electric car is the better option? Start with a list of pros and cons for electric and diesel cars. Do research on this topic and argue carefully in the end.

Activity 3.1: What do students learn when dealing with SSI?



- What do students learn when dealing with such a task?
- Should SSI be included in science and mathematics lessons? Why?

What do students learn when dealing with SSI?

Research has shown that SSIs can be used

- as contexts for learning scientific content (Applebaum et al. 2006; Walker 2003; Zohar and Nemet 2002)
- for understanding the nature of science (learning 'about science')
- for citizenship education (Herman et al. 2018; Radakovic 2015; Sadler et al. 2007).
- In this respect, the authors highlight the following important aspects when dealing with SSIs:
  - recognizing the inherent complexity of SSIs,
  - examining issues from multiple perspectives,
  - appreciating that SSIs are subject to ongoing inquiry,
  - exhibiting skepticism when presented with potentially biased information.

Activity 3.2: How to design a lesson dealing with this SSI?

Plan a science lesson dealing with SSI‘s:

- Sketch the timeline and the scientific content of the lesson.
- Elaborate especially the following details.
  1. Which SSI(‘s) will the students be dealing with?
  2. Why did you choose this SSI?
  3. What are the core learning outcomes?