Stem, Diversity and Contexts

Aims of the Module

- understanding the value of using contexts in IBL tasks in science and mathematics to support the learning process by making connections between context and concepts and apply this in classroom teaching
- being able to find and use real-life, relevant contexts for IBL in daily science and mathematics teaching
- enabling students to apply science and mathematics in real life contexts.
- understanding how real-life relevant contexts (e.g. genetic engineering, climate change, oil drilling) and scientific and moral reasoning can promote fundamental values of our societies and apply this in classroom teaching
- understanding how the use of contexts in science and mathematics IBL tasks can support inclusive education and intercultural learning and apply this in classroom teaching
- understanding the nature, applications and implications of science and mathematics for societies
- making students understand that scientific decisions based on science /mathematics are also influenced by moral, ethical and social reasons.

Ways of working

- Reflecting on existing beliefs and practices regarding addressing diversity and regarding IBL
- Providing and discussing concrete subject-specific examples
- Developing and reflecting on important principles for addressing diversity in science and mathematics classrooms
- Experimenting with and reflecting on using IBL for diversity

Structure & Length of the Module

Overall length of the module: 270 minutes (+30 optional) + 135 minutes homework
You may change the order of activities as you see fit, but keep in mind the notes we added about connections between activities in the descriptions.
Overview of the sequence of the activities.

Activity 1: Context based teaching of mathematics and science

Activity 2: Examples of contexts

Activity 3: Contexts, socio-scientific issues and fundamental values

Activity 4 – Designing and presenting a SSIBL lesson plan

Activity 5 – context-based education and overcoming drawbacks

Activity 1: Context based teaching of mathematics and science (60 + 30 minutes)

Part a: Introduction and exploring *experiences* with the use of contexts (10 min)

The aim of this activity is to look back on the activities from module 1 (especially the homework activity 6), that focused mainly on diversity in achievement, and to introduce the focus, aims and structure of this module on the use of contexts in IBL tasks and to collect teachers own experiences with the use of IBL connected to contexts in their teaching. After a more general introduction in this activity, we will narrow the focus to real-life contexts that are relevant to society in activities 2-4.

Briefly introduce the aims, ways and working and activities for this module and its session(s). Make clear that the focus shifts from IBL in relation to diversity and achievement to IBL in realistic contexts related to different aspects of diversity, such as interest, culture, values etcetera.

Then continue by inventorying contexts used by the participants.

- Ask participants to think of an example, in which they used real-life authentic contexts (situations or problems) in their teaching. Refer to the IBL lesson plans they each designed in module 1 (activities 4 and 6): did they use contexts in these activities?

- Collect the contexts on the (white)board or flip-over for later use in activities 1b and 1c. Note the title and/or the topic of the context. Do not yet discuss them.
  Note: if participants do not teach the same subject, you may want to have them briefly explain some more about the way the context is related to their subject.

The list of contexts will be referred to in the next activities (1b and 1c) when discussing the relevance, benefits and challenges related to the use of contexts. The list of contexts can help make the discussions more concrete and practical. If no or only a few contexts are listed you may want to add contexts to the list yourself and provide participants with some more examples (see also worksheet 2). You may also use the collection of classroom worksheets on the MaSDiv-website that comes with the course for this purpose.

Activity 1b: Reasons for the use of contexts - from practice and theory (20 minutes)

The aim of this activity is to have participants share and discuss reasons for using contextualised IBL-tasks and the benefits this can have for their teaching and their students. By relating the benefits listed by the group to benefits from literature, teachers expand their knowledge and become aware of the variety of reasons to use contexts and the different roles contexts can have.

Continue exploring the contexts listed in activity part 1a.
First have participants in pairs (or small groups) exchange their reasons for using the specific context they did and to discuss the advantages or benefits this had for their students.

Note: It is important to pay attention to the way of grouping the participants.

- If some participants have no experience with the use of contexts in their teaching you may form mixed groups with teachers who have and who don't have experience using contexts.
- If participants teach different subjects you may consider making single-subject groups.
- If not enough contexts are listed or if you want everyone to discuss the same example or if you want to use an example that is typical for a specific subject you may provide the examples yourself or you can use the exemplary contexts introducing exponential growth on worksheet 1.

Next ask participants to work in small groups and list, more in general, what they belief to be the relevance of contexts for their teaching and what benefits it has for their students. Collect and discuss these findings. For example have each group present their most important benefit. Specifically ask why they choose this one as being most beneficial.

Present the five advantages listed below of the use of real-life, authentic contexts for science and mathematics learning. These advantages are based on research findings[1].

Advantages/benefits of the use of contexts:

1. They motivate students to learn
2. They make it easier to remember concepts by providing more coherence, and making mathematics and science more concrete, less abstract
3. Students learn to apply concepts in real-life situations
4. Students learn about societal impact and experience the relevance of science and mathematics
5. Students learn about how decisions based on science (scientific reasoning) are taken and on the influence of ethical, moral, social and cultural aspects on these decisions

Reflect with the whole group how these advantages are the same or different from the advantages/benefits brought in by participants. The intended outcome is that participants become aware that motivation (benefit 1) is not the only or most important role of contexts and that contexts are not just useful as applications 'at the end' of a teaching sequence (benefit 3). Emphasize that contexts –at the start- can support the development of conceptual understanding and the use of academic subject-language (benefit 2). You may refer to the definition below:

> Context-based approaches are approaches adopted in mathematics and science teaching where contexts and applications of mathematics and science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications.
> source:
> http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=FB895DF1650B6C5755C6DFC1A77E3F0B?doi=10.1.1.433.6505&rep=rep1&type=pdf

Also emphasize that benefits 4 and 5 (see list above) get more and more attention over the last years and are central in this course. Real-life contexts provide the opportunity to address so-called socio-scientific issues. These contexts show the relevance of scientific reasoning to society and promote fundamental values by connecting to moral aspects. Examples of such real-life relevant contexts will be discussed in the activity 2.

Activity 1c – Optional extension of theoretical background on the use of contexts (30 minutes)

The aim of this optional extension to activity 1b is to have participants reflect on the use of contexts by discussing statements related to literature to deepen and broaden their understanding of the way they can use contexts effectively in their teaching, They read excerpts from research publications and formulate and discus statements.

Note: Whether or not you want to use this activity with your group may depend on the experience participants have in using contexts. The risk of using it in the case they do not have much experience

[1] See references and worksheet 3 and the optional activity 1c

is that the discussion will be mainly theoretical and participants cannot relate this to their own teaching. You can decide to skip this activity or do it later. In activity 1d a brief summary of the role of contexts is presented.

Ask participants to read the texts (four fragments) on context-based education on worksheet 3 and formulate a statement (or question) to discuss in the whole group.
Note: You may want to distribute the four fragments between participants.

Discuss the statements and questions formulated by the small groups. Use an activate way of working, for example the 'inside-outside discussion-circle'.

- Split your group and make an inside and an outside circle, participants facing each other.
- Ask one of the participants to pose his/her statement/question.
- Give 10 seconds to individually think of a reaction.
- Next ask participants in the inside-circle to share their response with the partner facing them (the partner listens). (30-60 seconds).
- Next change roles: outside circle reacts on what he/she has heard.
- Optional: add a 1 minute discussion between partners.
- Have the outer circle step one 'partner' to the right.
- Repeat the process. Either discuss the same question/statement or ask one of the participants to bring in a new statement question.

In the whole group you may want to summarize what participants learned in addition to the outcomes of activity 1b and how this helps their teaching,

Activity 1d: Contexts in textbooks (30 min)
The aim of this activity is to have participants apply their knowledge of the use and benefits of contexts in a more practical setting by classifying and characterizing contexts in their textbooks. If your textbooks do not have contexts in them, you can skip this activity.

Have teachers first read the text below that summarizes theory about contexts (or present it yourself). Note: More theoretical background on the use of contexts can be found on worksheet 3 and

> Contexts in science education encompass a wide-ranging body of knowledge that is not easy to define. While the term is widely used in education, it is difficult to define consistently. An attempt that connects contexts to support students in learning a concept: *A context is a practice or situation in which a concept is used and which is meaningful to students or can become meaningful to them by their activities.* A practice is for instance: transportation, food preparing, medical services. A situation is for instance: the rainbow, vaccination, crystallization.
>
> Contexts can for instance be 'nice' dresses of traditional textbook tasks to give the impression that science is fun (1), or can be related to an authentic practice for showing relevancy and applicability in future work (2), or can be related to a socio-scientific issue for showing the importance of scientific knowledge in daily life (3).

Next, ask teachers in small (mono-disciplinary) groups to look for contexts in their textbooks and identify the situation or practice and the incorporated concept (referring to the definitions above). Also ask them to identify the role in terms of the three roles numbered in the text above. Next have them discuss their teaching experiences with one or more of these contexts. Based on this discussion ask each group to formulate one recommendation about the use of the contexts in textbooks.

Collect the recommendations and briefly discuss them: what does this mean for their own teaching practice?

The intended outcome is that teachers more consciously work with the contexts in their textbook, are able to recognize roles of contexts and can make use of the benefits. Possible recommendations are:

- make sure you (as a teacher) know the role of the context and make your students know this as well
- talk about the context with your students to get them involved and motivated
- if the context is relevant to society, be aware that it may connect to students values and beliefs. Try to connect this to the role and influence science has in relation to these. Take some time to discuss this.
- you (as a teacher) may add a fitting context to a concept for several reasons connected to the three roles stated above.

In the discussion difficulties of using contexts may be pointed out. In activity XXX some of these drawbacks will be discussed.

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Activity 2: Examples of contexts (60 minutes)

The aim is for the participants to be able to find, use and analyse real-life relevant contexts for IBL in their teaching. They work on this aim by studying some concrete examples and discussing the roles, benefits and advantages as well as the opportunities and challenges each context presents for developing conceptual understanding and addressing fundamental values.

This activity consists of two parts.
- in part A you 'model' a discussion on the use of an exemplary real-life relevant context
- in part B participants explore and discuss a selection of contexts in small groups and report their findings

Part a - Whole group discussion of an exemplary context (15 minutes)
Discuss one context with the whole group using the question below. Lead the discussion yourself. This part is meant to model what you want small groups to do in the next part of the activity. It will also provide you with information on what participants already know and how experienced they are in this topic. Based on this you can decide how to proceed with this activity.

Give participant some minutes to read the context below. This context can be used for a lesson related to the question: *Can the earth feed us – is their enough food?*

> **Meat or vegetables**
> Most people in the world are vegetarians. The main crops are wheat, rice, corn and potatoes. Eating meat is one of the rich Western diets, and this is questionable from an environmental perspective. Cattle herds in the world use larger and larger land-areas, more water and energy.
> An increasing proportion of the world's cereal production is used to feed animals. But the animals have a low efficiency. When the grain is passing through animals, 96% of the calories are 'lost' and only 10% of the protein from the grain remains in the animal. Conclusion: the more animal products mankind eats, the less people can be satisfied
> Source: Medan Jorden Snurrar, 2000, p.77

Ask participants to think in pairs (5 minutes) about the following questions related to this context:

Questions
- What subject-specific content and concepts (and questions and activities) can be related to this context?
- What role can the context have and what are benefits of the use of this context?
- Which opportunities and challenges does this context present for:
  - IBL?
  - Promoting scientific literacy?
  - Being relevant for society?
  - Addressing fundamental values?
  - Inclusive education? (see module 1 for a list of characteristics).

Lead a group discussion. The aim is to hear the following (if necessary provide this yourself):
- This context can be related to concepts from biology and mathematics (and economy) like nutritional value, area, ratio. These concepts may be made richer or more meaningful by applying them in this context and seeing the practical value.
- The context can be motivating for students because they can connect to it (their future) and

students are presented with dilemmas about social justice and scarce resources as well as what they like to eat and what they should eat.
- The context facilitates IBL when having students collect facts about the world food situation.
- World population and food situation are relevant issues for society. Several aspects can be connected: The western diet (meat) is expensive; worldwide (unfair) sharing of food; the availability of healthy food; the agricultural situation etc..
- Classroom culture and norms can contribute to inclusive education: respecting each other's ideas, collaborating, making decisions together in a 'democratic' way, etc.

Note: a full worksheet of a lesson related to this context is available at the MasDiv-website

Part b – analysing and discussing contexts (30 -40 minutes)
Have participants work in small groups on a selection of contexts (see worksheet 2a for references to the collection of classroom worksheets on the MaSDiv-website). Participants analyze and discuss the contexts with respect to the question below.

Question:
- What subject-specific content and concepts can be related to this context?
- What role does the context have and what are benefits of the use of this context?
- Which opportunities and challenges does this context present for:
    - IBL?
    - Promoting scientific literacy?
    - Being relevant for society?
    - Addressing fundamental values?
    - Inclusive education? (see module 1 for a list of characteristics).

Notes:
- If you want to use the contexts you collected in activity 1a from participants, make sure there is more than just a title. Participants need enough information to be able to discuss the question.
- You can make a pre-selection of the examples you want participants to discuss and you may want to distribute examples among the small (subject-specific) groups or indicate the number of contexts to analyse. Keep in mind that some context will be used later in this module in activities 3 and 4 you may want to keep them out of this activity.

Have each group write their findings (per context) on a flip-over-sheet, to share these in the whole group in the form of a poster-presentation. You find an exemplary format for such a poster on worksheet 2c.

Summarize the findings in a whole group discussion. This should contribute to the understanding of participants that one can take into account a variety of aspects when selecting and using contexts for teaching.

Activity 3: Contexts, socio-scientific issues and fundamental values (60 minutes)

The aim of this activity is to have participants become aware how the use of real-life and (for society) relevant contexts around socio-scientific issues can promote scientific and moral reasoning by addressing fundamental values of our societies. A further aim is to enable teachers to apply this in their classroom teaching and to make students understand that decisions based on science and mathematics can also be influenced by moral, ethical and social reasons.

part a – socio-scientific issues connected to contexts (30 minutes)
In this activity you may use one or both of the following (classroom) examples that address socio-scientific issues and fundamental values.

- Can the earth feed us (biology and mathematics) –classroom worksheet on masdiv-site
- Fisheries (physics and chemistry) –classroom worksheet on masdiv-site

Hand out the worksheet(s) and give participants about 5 minutes to quickly glance through the activities. Ask them to discuss in small groups what issues are at stake in each of the examples.

Collect and discuss the findings. Try to focus on global issues, for example:

- For food – the (un)fair distribution of the earth's resources and possible solution.
- For fisheries – the 'ecological damaging' use of a scientific discovery (TNT).

Next – referring to the outcome of the discussion- present a definition of Socio-scientific issues (SSI) and four goals (see boxes below).

Socio-scientific Issues (SSI) are controversial social issues which relate to science. They are ill-structured, open-ended problems which have multiple solutions.
SSI are utilized in science education in order to promote scientific literacy, which emphasizes the ability to apply scientific and moral reasoning to real-world situations. Some examples of SSI include issues such as genetic engineering, climate change, animal testing for medical purposes, oil drilling in national parks, and "fat taxes" on "unhealthy" foods, among many others. Research studies have shown SSI to be effective at increasing students' understanding of science in various contexts, argumentation skills, empathy, and moral reasoning.

source: https://en.wikipedia.org/wiki/Socio-scientific_issues

Supporters of SSI argue that it can:

1. Cultivate a scientifically literate citizens who are able to apply evidence-based scientific content knowledge to real-world socio-scientific scenarios;
2. Foster a collective social conscience whereby students consistently reflect upon the formation and implications of their own reasoning;
3. Encourage argumentation skills that are essential for thinking and reasoning processes and mirror the types of discourse utilized in real-world scientific deliberations;
4. Promote critical thinking skills, such as analysis, inference, explanation, evaluation, interpretation, and self-regulation[5]

Science educators often refer to all of these aspects together as, "functional scientific literacy."[6]

source: https://en.wikipedia.org/wiki/Socio-scientific_issues

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Ask participants (again in small groups) to discuss if and to what extend the two classroom examples have characteristics of SSI and can contribute to each of the four goals. Also discuss if they would use these (kind of) activities in their own classrooms? Why? Why not?

part b – Connect to OECDs notion of global competency[2] (30 minutes)
The OECD aims to have education prepare future citizens to have global competences. They state:

> "If young people are to co-exist and interact with people from other faiths and countries, open and flexible attitudes, as well as the values that unite us around our common humanity, will be vital. Curricula will need to be comprehensive, interdisciplinary and responsive to an explosion of scientific and technological knowledge."
> (OECD, 2016)

In the questionnaire they presented to schools they asked if in the curriculum attention is paid to global challenges and trends (that contribute to global competency) by presenting a list of topics.

Ask all participants to individually select three topics from the list, that they consider important to teach and that they can include in their teaching practice.

Form groups of participants that made the same choice and ask them discuss their reasons for selecting this topic.

In a whole group discussion focus on the reasons:

- Are reasons mainly practical: it fits the curriculum, they already use the context in their teaching, it is in the textbook etc.
- Are the reasons related to possibilities to use IBL and address diversity in achievement (module 1)?
- Are the reasons for choosing the topic related to science itself? Do they see benefits for concept-development or scientific reasoning?
- Are the reasons connected to the relevance of the context for society? Do they see possibilities for moral reasoning and addressing fundamental values?

Climate change and global warming
Global health (e.g. epidemics)
Population growth
Migration (movement of people)
Impacts of developments in the global economy
Air pollution
International conflicts
Hunger or malnutrition in different parts of the world
Causes of poverty
The pace of technological change in the world
The impact of ageing populations
Equality between men and women in different parts of the world
The consequences of clearing forests for other land use

Activity 4 – Designing and presenting a SSIBL lesson plan (60 minutes)

[2] see: https://www.oecd.org/education/Global-competency-for-an-inclusive-world.pdf

The aim of this activity is to have participants reflect on characteristics of SSIBL-lessons, study some examples and use these to have the participants prepare (and use) a teaching activity for their class incorporating the elements addressed in this module: using a context-based approach, addressing socio-scientific issues and fundamental values.

Part a – characteristics of a lessons using SSIBL (15 min)
Present the handout characteristics of an SSIBL lesson on worksheet 4Have participants in small subjects-specific groups discuss the feasibility of using this handout as a guide for designing a lesson/activity.

Part b – Examples and ways to address SSIBL (15 minutes)
Have participants in the same groups discuss the half worked out examples of SSIBL-lessons (dilemma's) on worksheet 5 and the suggestion to use topics from the news on worksheet 6.

In the whole group ask if these examples and the ones used in the previous activities inspired them to develop a first version of an SSIBL example to use in their own teaching.

Part c – Design a first version of a SSIBL-lesson or activity (30 minutes)
Have participants work in (the same) subject specific small groups on a first outline of an SSIBL-lesson or activity to use in their teaching. Have them:

- identify the class, the topic and the elements they want to include (context, ssi, values…);
- formulate clear/SMART learning goals and make sure the activity and teaching methods fit the goals;
- use the handout on worksheet 4 as a guide for the design

Use the last 10 minutes to have participants share the topic/context each group has chosen and to present the homework task.

Homework
Asks participants to finalize the design of the SSIBL lesson (or activity) in the form of a lesson plan and teaching materials and try it out in their class before the next meeting and report on it the next time.

This reporting can be done in several ways: it always includes the activity as presented to the students and one or two of the experiences for example in the form of: a three minute pitch; a (short) video; pictures from their class working on the activity; student work ….. etc.

Use the sample evaluation form to report on your experiences (see worksheet 7).

Activity 5 – context-based education and overcoming drawbacks (30 minutes)

The aim of this activity is to have participants reflect on the drawbacks of contexts and ways to prevent or overcome them.

Part b – preventing drawbacks (20 minutes)

Collect drawbacks (disadvantages) participants see with the use of contexts in their teaching. These may have risen during the previous activities. List drawback on the whiteboard or flipover.
Note: you may want to add typical drawbacks as listed below (these are produced in other PD-courses).

Advantages/benefits of contexts	Disadvantages/drawbacks of contexts
1. Motivating to learn	1. More language, concepts from the context
2. Easier to remember, bring more coherence	2. More time needed
3. Student learns to apply concepts	3. Concepts remain linked to the one context
4. Students learn about societal impact and how decisions based on science are taken and can be influenced by moral ethical and cultural considerations	4. Unclear what is learned
5. Contexts indicate selection of concepts	5. Realistic contexts sometimes too complex, not all scientific concepts fit to a context

Next asks participants in pairs or small groups to think of ways to overcome (or prevent) each of the listed drawbacks.
Finally collect the suggestion for preventing or overcoming the drawbacks and share them with the whole group. You may want to discuss which of the suggestions are easy to implement. Below you find examples resulting from other PD-courses, that you may want to bring in to the discussion.

Disadvantages of contexts	How to prevent?
1. More language, concepts from the context	Use visual elements like pictures, graphs, tables
2. More time needed	Contexts can be 'small'; not all lesson need to be contextual;
3. Concepts remain linked to the context (no transfer)	Use more than one context connected to a concept; switch between stressing the contexts and stressing the concepts
4. Unclear what is learned	Contexts can help to make misconceptions or misunderstandings visible
5. Real-life contexts sometimes too complex, not all concepts fit in a context	Focus on specific elements; simplify (and make this clear); not all concepts need to be related to contexts

References

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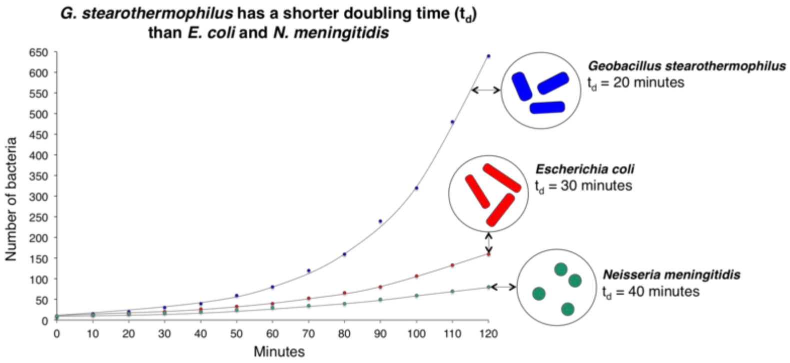
Worksheet 1 - Exemplary contexts to introduce exponential Growth

1. ***Money or rice on a chessboard*** (math)

   "If someone offered to place a bet with you, and you had your choice of $100 or a set of pennies, which would you choose? Before you decide, keep in mind that the number of pennies would be determined by the following rule: one penny is placed on a corner square of a chess board. Two pennies are placed in the square next to it. Four pennies are placed in the square next to it. The pennies are doubled again for the next square. This procedure is repeated until all squares on the chessboard have pennies in them."
   Investigate which option is the best to choose."
   Source and additional classroom activities on:
   https://www.pbslearningmedia.org/resource/vtl07.math.number.exp.lpgrowth/exponential-growth-introduced/#.WjfjlVSdX_S

2. ***Growth of bacteria doubling at regular intervals*** (biology)

   In the laboratory, under favourable conditions, a growing bacteria population doubles at regular intervals.



   Source: https://commons.wikimedia.org/wiki/File:G._stearothermophilus_has_a_shorter_doubling_time_(td)_than_E._coli_and_N._meningitidis.png

3. ***Radio-activity half-life*** *(chemistry, physics)*

   Half-life is the time required for a quantity to reduce to half its initial value. The term is commonly used in nuclear physics to describe how quickly unstable atoms undergo, or how long stable atoms survive, radioactive decay. The term is also used more generally to characterize any type of exponential or non-exponential decay. For example, the medical sciences refer to the biological half-life of drugs and other chemicals in the human body. The converse of half-life is doubling time. The original term, half-life period, dating to Ernest Rutherford's discovery of the principle in 1907, was shortened to half-life in the early 1950s.
   source: https://en.wikipedia.org/wiki/Half-life
   see also classroom experiment on:
   https://en.wikiversity.org/wiki/Physics_and_Astronomy_Labs/Radioactive_decay_with_dice

4. ***population growth*** (geography)

   Consider the doubling time of human population. It took roughly 300 years for human population to double from 500 million to 1 billion in 1804; from then, it took 113 years to double to 2 billion, and 47 years to double to 4 billion. Our population is expected to double to 8 billion by the year 2025, and the United Nations projects that human population will reach 9.6 billion by the year 2050. Graph this data. What can you tell about the growth?

Source: http://populationeducation.org/content/using-population-growth-explore-exponential-growth-and-doubling-time

Worksheet 2a – context examples

Example 1: Can the earth feed us
See classroom worksheet on the MaSDiv-website, this example will be used in activity 3

Example 2: Fisheries
See classroom worksheet on the MaSDiv-website, this example will also be used in activity 3

Example 3: Rope problems
See classroom worksheet on the MaSDiv-website
Note this context can function as non-example, since this is not a real-life relevant context.

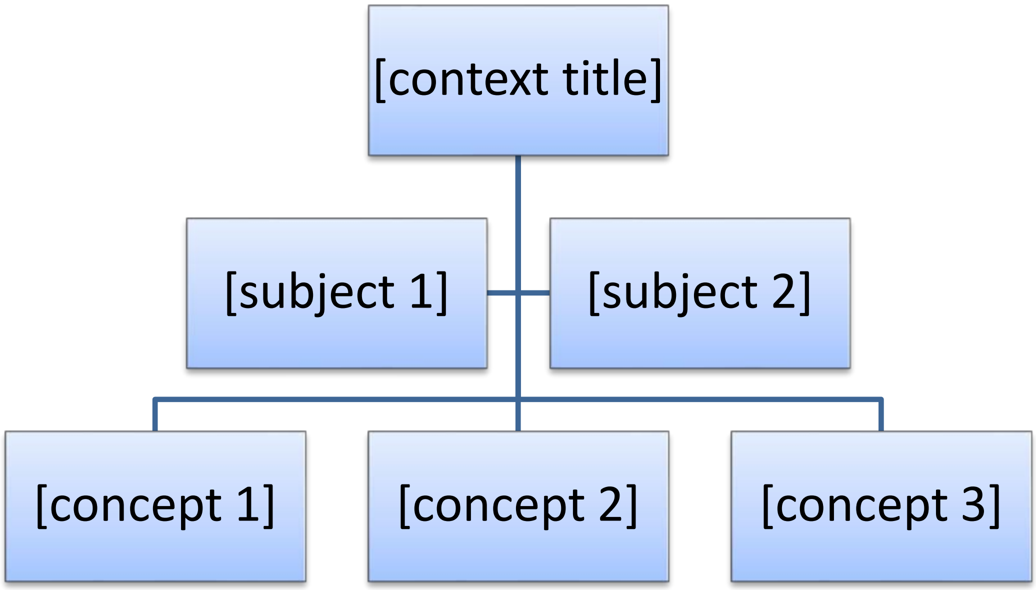
Example 4: Medical decisions
See classroom worksheet on the MaSDiv-website

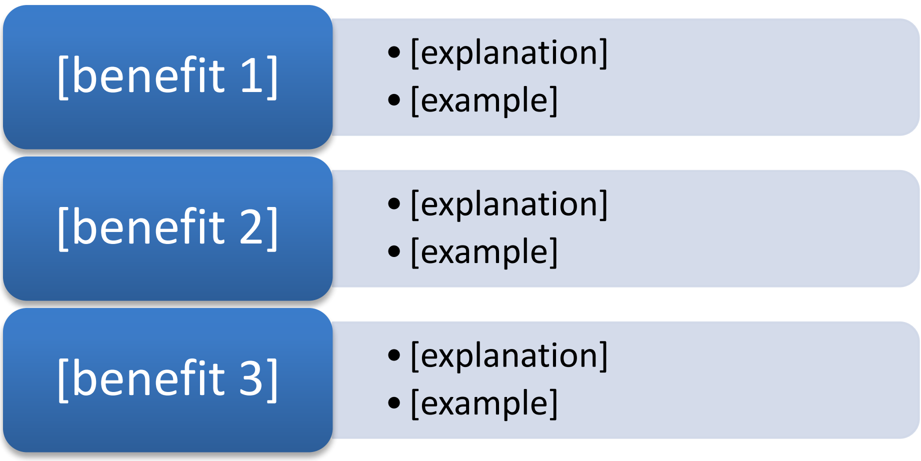
Example 5: Chocolate and child-labour
See classroom worksheet on the MaSDiv-website

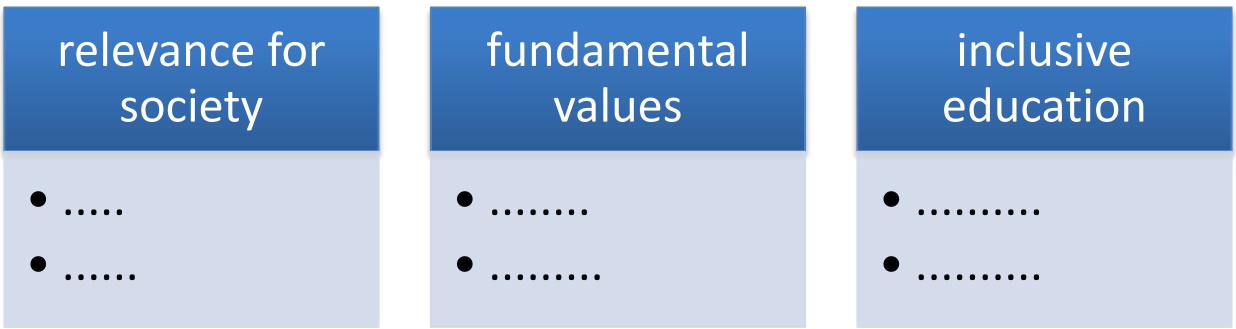
Example 6: Plastic soup
See classroom worksheet on the MaSDiv-website

Note
You may also want to use contexts on worksheet 1 and the contexts from module 1 and from teachers own lessons

Worksheet 2b – poster template







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Worksheet 3 – fragments from research literature

Parts of: http://alexandria.tue.nl/extra2/724553.pdf
de Putter- Smits, L.G.A., (2012): *Science teachers designing context-based curriculum materials: developing context-based teaching competence*. Eindhoven School of Education.

Chapter 2 p. 9

In this study the definition of a context-based learning environment follows that of the context-based approach by Bennett et al. (2007) in their review of research into the subject: "Context-based approaches are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications" (p. 348). To describe the nature of the contexts used in context-based education we follow Gilbert (2006). According to Gilbert (2006), contexts should have:

> *a setting within which mental encounters with focal events are situated; a behavioural environment of the encounters, the way that the task(s), related to the focal event, have been addressed, is used to frame the talk that then takes place; the use of specific language, as the talk associated with the focal event that takes place; a relationship to extra-situational background knowledge (Duranti & Goodwin, 1992, p. 6-8).*

An important element of a context-based learning environment is active learning (Gilbert, 2006; Parchmann et al., 2006): the students are required to have a sense of ownership of the subject and are responsible for their own learning. The combination of self-directed learning and the use of contexts is consistent with a constructivist view of learning (Gilbert, 2006). As current research in science education points out: people construct their own meanings from their experiences, rather than acquiring knowledge from other sources (Bennett, 2003).

Chapter 3 p. 39-40

The context-based approach is often proposed to counter the shortcomings in traditional science education. In a review by Gilbert (2006) the shortcomings of traditional chemistry education are summed up:

1. Overload [...], curricula have become over-loaded with content [...]. The consequences of high content loads have been that curricula are too often aggregations of isolated facts detached from their scientific origin [...].
2. Isolated Facts. These curricula are being taught without students knowing how they should form connections within and between the aggregations of isolated facts. [...] This can only lead to low engagement in classes and the forgetting of material thereafter.
3. Lack of transfer. Students can solve problems presented to them in ways that closely mirror the ways in which they were taught. They signally fail to solve problems using the same concepts when presented in different ways. [...].
4. Lack of relevance. When chemistry ceases to be a compulsory subject in the curriculum (usually at the minimum school-leaving age), the great majority of students does not elect to continue to study it. Moreover, many of those that do elect to continue to study the subject experience a lack of relevance in it and seem to view it in an instrumental way, [...].
5. Inadequate emphasis. The traditional emphases of the chemistry curriculum have been the provision of a 'solid foundation' [...], 'correct explanation' [...], and 'scientific skill development' [...] as the basis for more advanced study of chemistry. However, this set of emphases is, on its own, increasingly seen as an inadequate basis for such study (p. 958).

Parts of: http://onlinelibrary.wiley.com/doi/10.1002/tea.20203/epdf
Rivet, A. & Krajcik, J. (2008). Contextualizing instruction: Leveraging students' prior knowledge and experiences to foster understanding of middle school science. Journal of Research in Science Teaching, 45(1), 79-100.

pages 80-81
Within the project-based science model, there are four characteristics of contextualizing instruction. The first is the use of problems and situations as the focus of instruction that are meaningful to students, in that they have implications to students outside of school (Edelson, Gordin, & Pea, 1999). Research has found that students sustain their attention more continuously and process information at deeper levels when they have a personal interest or investment in the domain (Brophy, 1998). However, it is not sufficient for the problems only to be of interest. They must also encompass worthwhile science content and leverage students' interest or experience for them to engage with the content. The second characteristic is that the meaningful problem provides a need-to-know situation to learn specific scientific ideas and concepts. The problem situation motivates a reason to understand the content and engage in the task of science learning, and provides a purpose for knowing science ideas and concepts (Krajcik et al., 2002). The third characteristic is the use of some form of anchoring situation and event (CTGV, 1992b; Marx et al., 1997) to engage students with the scientific concepts that are addressed in the problem or situation, and it revisited repeatedly during instruction. Anchoring events provide students with a common experience from which they can relate new information (Sherwood, Kinzer, Bransford, & Franks, 1987). Experimental research has shown that rich contextualizing features such as anchoring events promote memory recall and subsequent transfer of information to new settings (CTGV, 1992b). The fourth characteristic is engagement with the meaningful problem over an extended period of time (Marx et al., 1997). Extended study allows for analysis of the problem from multiple perspectives. The Center for Learning Technologies in Urban Schools (LeTUS) has developed science curriculum materials that incorporate new ideas about teaching and learning through project-based instruction that fosters contextualizing students' experiences (Krajcik, Blumenfeld, Marx, & Soloway, 1994; Krajcik et al., 2002; Marx et al., 1997). Contextualization is one of the seven design principles for project-based science (Singer, Marx, Krajcik, & Clay-Chambers, 2000). Within each LeTUS project-based science unit, there are five design features that support contextualizing instruction: (1) there is use of a driving question to introduce and structure the context of the project; (2) there is an anchoring event or experience that all students share; (3) the project activities are linked and woven in with the driving question and contextualizing theme; (4) student artifacts or projects related to the contextualizing theme are developed during the unit; and (5) there is a culminating event or experience bringing closure to the project (Rivet & Krajcik, 2004).

Page 82 Proposed Benefits of Contextualizing Instruction
Contextualizing instruction has been theorized to help students make sense of complex scientific ideas, because the use of meaningful problems or situations provides students with a cognitive framework for which to connect or ''anchor'' knowledge (CTGV, 1992b; Kozma, 1991). The cognitive framework acts like a structure upon which abstract ideas can be linked with prior understanding and fixed in long-term memory. In this way, the use of meaningful problems over extended periods of time makes the learning situation ''bushier'' (Kozma, 1991) with more available links onto which students can connect ideas. Learning occurs when new information is ''hooked'' and embellished by previous knowledge held in memory (McGilly, 1994).
Classroom tasks influence students by directing their attention to particular aspects of the content and specifying ways to process information (Doyle, 1983). Contextualizing instruction focuses students' attention on the interrelationships between concepts. This is in contrast to more subject-specific instruction that emphasizes the presentation and recall of information but not necessarily the connections between them. In addition, contextualizing instruction helps learners to organize

and integrate knowledge by engaging students with scientific ideas from multiple perspectives while pursuing solutions to meaningful problems (Blumenfeld et al., 1997). Through engagement with concepts and ideas from different perspectives, students see how the ideas are applied in different settings and build their own representations of concepts (Marx et al., 1997). Meaningful problem situations also provide learners with a perspective for incorporating new knowledge into their exiting schema, as well as opportunities to apply their knowledge (Edelson et al., 1999).
Contextualizing instruction is believed to promote transfer of science ideas to other contexts, because students learn to relate content idea to problems and situations meaningful in their lives and the real world. Rich contextualizing features promote memory recall and thus transfer (CTGV, 1992b, 1997). In addition, contextualizing instruction engages students in active use of their developing scientific understandings. Active learning, rather than passive reception, is needed for students to gain an understanding of the application of their knowledge under different circumstances. Active learning in multiple contexts is claimed to support the abstraction of knowledge, and thus transfer (Collins, Brown, & Holum, 1991). However, it has also been found that novice learners do not always make connections between new information and prior knowledge or everyday experiences in ways that are productive for learning (Land, 2000). Some have argued that due to the underdeveloped knowledge structures and the lack of experience of novice learners, engaging them in effective theory-building in everyday contexts which can be considerably complex may be overly optimistic and, at times, counterproductive. Novices may misapply prior experiences or use observations to unknowingly strengthen their naive theories. Although there are many benefits in building upon meaningful problems and real-world situations, the instructional challenges associated with effectively realizing these benefits are formidable (Land, 2000).

Worksheet 4 – characteristics of Socio-Scientific Inquiry Based Learning (SSIBL) lessons[3]

Characteristics	
Controversial topic	Developments in scientific research often influences our society. These innovations can lead to both personal and societal dilemma's, called **Socio Scientific Issues** (SSI's). A SSIBL-lesson uses an SSI as a starting-point. The SSI is a dilemma; people have different opinions about the issue and there is no clear answer to it. Think for example about the use of biotechnology. To which extend biotechnology can be integrated in our society, is a societal issue raised by scientific research and innovations in life sciences. In order to set up a good SSIBL-lesson, you clearly need knowledge about not only your own discipline, but also about for example social sciences and ethics. More examples from SSIBL-topics are attached to this document.
Perform research using different kinds of resources	Let pupils set up and investigate their own research questions about the topic. Here the **Inquiry Based Learning (IBL)** part of SSIBL is covered. The pupils perform their SSIBL-research not only using the scientific method; also methods from social sciences should be incorporated. Think about taking interviews with important stakeholders or spread questionnaires to investigate opinions.
Dialogue/communication	Plan a moment in your lesson for pupils to discuss their results. A classical dialogue is an suitable method, but also think about communication via different kinds of (new) media. Support the pupils in choosing their communication method.
Action	A SSIBL-research ideally leads to concrete action. Support the pupils in taking action based on their SSIBL-research. Let them make their own choice in what the most appropriate action should be, and let them organize and do it. Make sure the pupils afterwards reflect on the changes that occurred because of their action. When there is no action possible at this moment, be explicit about why this is the case. Discuss the action potential in the future with the pupils.

Worksheet 5 – Examples of SSIBL lessons[4]

3 PARRISE Promoting Attainment of Responsible Research & Innovation in Science Education developed for the parrise-project, may 2015

Topic	SSI - dilemma	Knowledge	Dialogue/communication	Action
Sun-tanning parlours	Should sun-tanning parlours be banned for young people under the age of 18?	<u>Scientific:</u> Radiation Structure of the skin <u>Other:</u> Risk and uncertainty Human Rights Freedom of choice Decision making	Dialogue on research outcomes; e.g. how important is freedom of choice in this issue, to what extend can governments force this restriction on the society?	Set up an educational campaign at school and/or social media.
Antibiotic-resistance	Is a uniform policy for the prescription of antibiotics needed, to prevent global resistance?	<u>Scientific:</u> Bacteria Antibiotics Infectious diseases <u>Other:</u> Policies in different countries Risk and uncertainty Legalisation Decision making	Dialogue on research outcomes; e.g. reasons for the differences in antibiotic-policy between countries, how different policies influences resistance of bacteria.	Write a message to the ministry of public health in your own or another country.
Recycling paper	Should we stop recycling paper, because the recycle-process costs money and effort and also burdens the environment?	<u>Scientific:</u> Chemical structure of paper Manufacture of paper Environmental burden <u>Other:</u> Cost-benefit analysis Decision making	Dialogue on research outcomes; e.g. how much attention should be paid to costs and environmental burden in this issue, what came out of the comparison between costs and environmental issues?	Make your own decision regarding paper recycling: do you decide to stop or continue?

Co-funded by the Erasmus+ Programme of the European Union

Worksheet 6 – science in everyday live

A very simple and easy way to include SSI in your lessons is to have your students follow the news (paper, twitter, television etc) for one week and let them collect news items which involve science or scientific findings.
Next, share their findings in class and discuss the issues related to the topics. You can either do so in a whole class discussion or have small groups each present one topic they find most interesting on n a poster or ppt-sheet.

The main focus of this activity is to make the students aware of how much of their day to day life has a scientific background. Scientific literacy is for example relevant in games, travelling, new products, lifestyle and diets.   Of course you can extend this activity over a longer time, or have language involved and have students write an article for the student paper/website.

See for an example on how to integrate scientific reading and ICT:
https://www.sciencebuddies.org/blog/your-digital-classroom-assigning-science-reading-with-science-buddies-google-classroom-integration

worksheet 7 – evaluation form

Name			
School			
Subject		grade	
Which activity was used (short description of resources and teaching method(s))			
How does your activity involve students in inquiry-based learning?			
How and why do you think that your activity will address diversity in achievement levels?			
Experiences during the lesson: what student behaviour did you observe (different than normal)? What did you observe with respect to different achievement levels?			