ENSITE
Environmental Socio-Scientific Issues
in Initial Teacher Education

Module 11

SCAFFOLDING

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of the European Union

This outline is based on the work within the project Environmental Socio-Scientific Issues in Initial Teacher Education (ENSITE). Coordination: Prof. Dr. Katja Maaß, UNIVERSITY OF EDUCATION FREIBURG, Germany. Partners: UNIVERSITEIT UTRECHT, Netherlands; ETHNIKO KAI KAPODISTRIAKO PANEPISTIMIO ATHINON, Greece; UNIVERSITÄT KLAGENFURT, Austria; UNIVERZITA KARLOVA, Czech Republic; UNIVERSITA TA MALTA, Malta; HACETTEPE UNIVERSITY, Turkey; NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU, Norway; UNIVERSITY OF NICOSIA, Cyprus; INSTITUTE OF MATHEMATICS AND INFORMATICS AT THE BULGARIAN ACADEMY OF SCIENCE, Bulgaria; UNIVERZITA KONSTANTINA FILOZOFA V NITRE, Slovakia.

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General overview and aim

In this module future teachers in initial teacher education are introduced to support their students in dealing with complex environmental socio-scientific issues (SSI) by providing a scaffolding framework. Educational research has shown that students often struggle with open problems. Meta-knowledge about the process to be followed can support students in dealing with these tasks and in deciding which step they should perform next.

The intention of this module is to strengthen future teachers' competences in how to use scaffolding and meta-knowledge frameworks to deal with environmental SSI and to develop a deeper understanding of the benefits for their students through meta-knowledge approaches.

Teacher students learn about scaffolding frameworks by using the topic "forest and climate change", an example of an SSI with multiple references to life experiences of future science teachers and their future students at school.

This module is part of:

- LEARNING: Developing competences in dealing with environmental SSI themselves
- TEACHING: Acquiring teaching skills to supporting their students in developing these competences

Both aspects relate to (i) scientific competences, (ii) transversal skills like critical thinking, innovative mind-sets and forward-looking skills and (iii) taking into account the social, ethical and cultural aspects related to SSI when making decisions.

IO11 builds on the introductory module IO1 and concretises its core contents by relating to a specific context. Module IO11 relates to modules IO3 Collecting Data and IO4 Analysing (big)data and is closely linked to Modules IO9 and IO10 Designing a SSI lesson I and II as well as IO12 SSI and assessment of student learning.

Relevant topics

This module presents and offers activities for teacher education intended to equip prospective teachers with the knowledge and skills to use and develop scaffolding frameworks and meta-knowledge, that supports lower secondary students in dealing with open complex problems. Future teachers are shown how to do so by addressing the following topics.

- forest and site
- forests in change
- forests and climate change

Using these examples future teachers will gain a first insight into how they can include current environmental issues into their lessons. They will also learn how to adapt it to age and achievement level of their specific students.

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Learning Outcomes

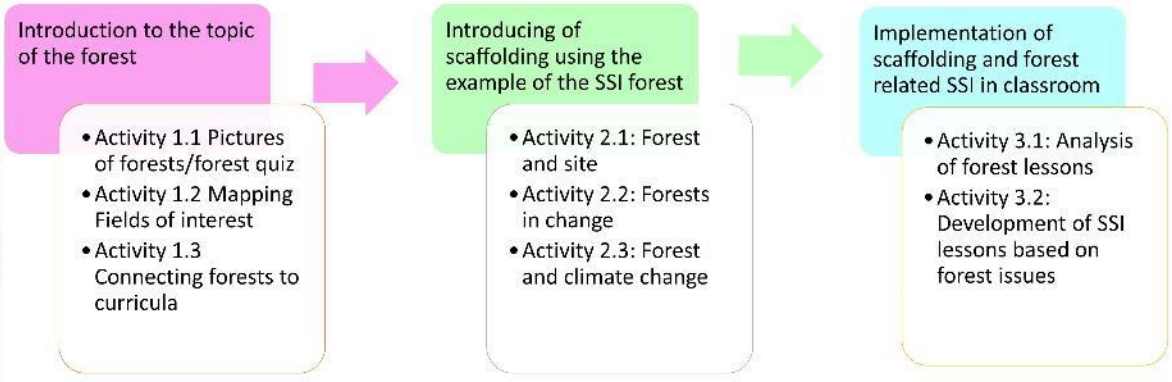
Students will acquire (adapt and finish)

- Experience in dealing with environmental socio-scientific issues involving forests (Activity 1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.2)
- Awareness of everyday ecological issues that are suitable as a basis for SSI teaching (Activity 1.1, 1.2)
- Skills on how to explore, analyze and recognize interrelationships (Activity 1.2, 2.1, 2.2, 2.3)
- Awareness that dealing with environmental socio-scientific issues can be linked to the goals of mathematics and science education (Activity 1.3, 2.1, 2.2)
- Awareness about the necessity that teaching science and mathematics should also include dealing with environmental SSI (Activity 1.3, 2.3)
- Examples of scaffolding connected to forest issues (Activity 2.1, 2.2, 2.3, 3.1)
- Skills on how to deal with them in an appropriate way (Activity 2.1, 2.2, 2.3, 3.2)
- Knowledge that dealing with environmental socio-scientific issues includes transversal skills like critical thinking as well as ethical, social, economic and moral issues (Activity 2.3, 3.2)
- Knowledge on the features of environmental socio-scientific issues and see that are different to "traditional" science and math's tasks (Activity 2.3, 3.1)

Flowchart and Module plan

This module involves three sections, all structured into several activities. It includes 785 minutes of sessions and 120 minutes of homework. It includes lecture parts, group discussions, debates and student presentations. The structure is as follows:

- Introduction into the topic: 180 min
- Introducing of scaffolding using the example of SSI forest: 380 min
- Implementation of scaffolding and forest related SSI in classroom: 225 min



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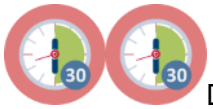
1. Introduction to the topic of the forest

1.1. Pictures of forests and forest quiz



Duration: 30 minutes +30 minutes

These are "warm up" activities. The intention is to give an impression of how different forests can look and to explore students' previous knowledge, beliefs, experiences, and attitudes related to the topic.

Pictures of forests

The trainer shows a selection of pictures with different forests (see worksheet 1.1a & presentation). The students have some five minutes to think about and then choose the picture of their favourite forest and tell a story about it.

The trainer asks the students to label their story with some keywords (1-5) and then assign them to one of the five posters located in the room. These posters have the headings: ecology, economy, society, culture, one is empty and offers space for everything that cannot be assigned to any of the others.

This activity aims to draw attention to the different dimensions of the forest. For example, from the perspective of Education for Sustainable Development, the forest has at least the following dimensions:

- Ecological: Forests are complex ecosystems that provide habitats for many animals and plants, preserve biodiversity and bind greenhouse gases.
- Economical: Forests are an economic area and a workplace, and sustainable raw material production is at the beginning of an entire value chain.
- Societal: Forests support human health and provide services to our society, such as protection, recreation and the provision of livelihoods. In return, we all bear the responsibility for preserving its resources.
- Cultural: Our history and culture shaped the forest and was shaped by it. Numerous fairy tales, folk legends and art are inspired by the forest.

If you want to draw more attention to these dimensions, you may insert this optional activity:

Forest quiz

The teacher trainer hands out cards to the learners. On each card there is a term that has to do with the forest. Each student tries to draw, explain (without using the term) or pantomime his or her forest term, the others try to guess the term. The guessed terms are assigned to one of the four dimensions of the forest (see worksheet 1.1b).

This session contributes to the achievement of the following learning outcomes:

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- Experience in dealing with environmental socio-scientific issues
- Awareness of everyday ecological issues that are suitable as a basis for SSI teaching

1.2. Mapping the field of interest

Duration: 30 minutes + 60 minutes

The following exercises are intended to give students an idea of the wide range of topics that are related to forests in the broadest sense.

Who knows about forest?

The class is divided into groups of three to four people. Each group is assigned a letter (A, B, C, ...) or a number (1, 2, 3, ...). The teacher trainer gives different terms related to the topic of forests (see worksheet 1.2a). The groups each have a few minutes to formulate their own definitions of these terms and write them down on a blank sheet of paper with the name of the group. Then the trainer collects all answers and reads out the correct and the students' definitions in random order in plenary. Each group gives a hint as to which definition they think is correct. They receive one point for each correct tip as well as for the correct definition.

In addition, learners can research and define terms themselves. The person who has written a question takes the lead for the respective game round.

Forest tales

The students are given the task of collecting information on the topic of forests (newspaper articles, photos, headlines, studies). In small groups they discuss what was decisive for them to choose articles, which of the materials seem credible, which seem interesting for teaching.

The topics addressed are collected and topic clusters are formed to form a pool for further tasks. (Topics could be e.g. forest use, species composition, accessibility, forest condition, forest fires, forest damage, forest in different cultures ...)

Alternatively, the collecting task can be given as homework in advance and only discussion and forming clusters takes place at school.

If time is short, the materials listed in worksheet 1.2b can be used.

This session contributes to the achievement of the following learning outcomes:

- Experience in dealing with environmental socio-scientific issues
- Awareness of everyday ecological issues that are suitable as a basis for SSI teaching
- Skills on how to explore, analyze and recognize interrelationships

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1.3. Connecting forests to curricula

Duration: 30 minutes

The activity is designed to show future teachers that environmental SSI can be used in a variety of ways in the classroom.

Forest links

The teacher trainer gives an example how to identify aspects in forest topics that relate to maths and science education.

The following section refers to the Austrian curriculum but can be transferred to national curricula as needed and adapted for different age levels.

According to the Austrian curriculum, the following should be achieved in lower secondary biology lessons:

- The pupils should learn to see principles, connections, cycles and dependencies and gain an understanding of scientific ways of thinking and working.
- They should understand the dependence of human beings on nature and the environment and acquire the knowledge to deal with them consciously.
- They should acquire a basic understanding of biology that will enable them to participate in social decisions.
- They should develop positive emotions for nature and the environment.

The subject matter of the 5th grade includes, among other things, the structure and way of life of vertebrates and flowering plants (especially representatives of the forest ecosystem), the development of basic ecological concepts on the basis of the forest ecosystem and the consequences of human activity. The knowledge is expanded and deepened in each subsequent school level.

A fifth grade biology lesson covering the SSI forest could, for example, survey which vertebrate species are commonly found in a native forest, what their feeding relationships are, what the disappearance of a species might cause, and what the causes of the disappearance of a species might be. This would address the learning objectives of knowledge about native animals, the basic ecological concept of food relationships and the consequences of human activity.

Following this example groups of two teacher students identify aspects in forest topics that relate to maths and science education for one subject and grade on their own.

Links to the national curricula (to be completed):

Austria: https://www.bmbwf.gv.at/Themen/schule/schulpraxis/lp.html

Cyprus

Czech Republic

Germany

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Greece Malta Netherlands Norway Romania Slovakia Turkey
This session contributes to the achievement of the following learning outcomes: • Experience in dealing with environmental socio-scientific issues involving forests • Awareness that dealing with environmental socio-scientific issues can be linked to the goals of mathematics and science education

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2. Introduction of scaffolding using the example of the SSI forest

2.1. Forest and site

Duration: 60 minutes

What does a forest need to grow, and which elements determine its appearance? The intention of this activity is to work out the connection between forest and site.

In the class, a forest tree is first used to work out what it needs for its growth.

To help students identify and name the correct components, the trainer shows students five objects or pictures, each symbolising a component: Light, water, air, nutrients and space (see worksheet 2.1a, presentation).

In a next step, the class looks into the question of how different plant species cope with different offers of light, water and nutrients and which species thrive where.

Tree profiles

In pairs, students create social media profiles of different forest trees. An example of this can be found on worksheet 2.1b. Descriptions of most European tree species can be found in the European Atlas of Forest Tree Species.

Alternatively, students can research trees themselves and create the appropriate profiles for them. The students can fulfil this task as homework as well.

Finally, the teacher trainer shows pictures of the forests of the earth: forests in different climate zones and at different altitudes (some examples in the presentation and on worksheet 2.1c incl. explanations). The students try to assign the forests to a geographical area, the climate zones, the altitude levels and to deduce the location factors that determine the appearance of the respective forest.

This session contributes to the achievement of the following learning outcomes:

- Experience in dealing with environmental socio-scientific issues involving forests
- Skills on how to explore, analyze and recognize interrelationships
- Awareness that dealing with environmental socio-scientific issues can be linked to the goals of mathematics and science education
- Examples of scaffolding connected to forest issues
- Skills on how to deal with them in an appropriate way

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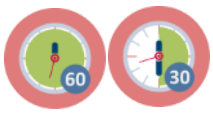
2.2. Forests in change



Duration: 90 minutes

Forests are dynamic. For thousands of years, the vegetation zones and the distribution areas of the individual species have been shifting depending on large-scale climatic changes such as the ice and warm periods.

The teacher trainer shows distribution maps of forests at different times (see worksheet 2.2a).

Global forest distribution (18.000 BC):

https://commons.wikimedia.org/wiki/File:Vegetationszonen_18.000_BC.png

Global forest distribution (2012):

https://es.m.wikipedia.org/wiki/Archivo:Vegetationszonen.png

The students compare the tables on forest cover in European countries in 1938 and 2011 and the data on forest cover in 2019 (see worksheet 2.2b). Optionally, the following exercises can be carried out in pairs or for homework: the students calculate the change in forest area for selected countries. How has the proportion of the country's area changed, and how has the area changed in absolute terms? What about global development is forest area also increasing here?

https://www.zeit.de/wissen/umwelt/2011-11/entwicklung-waldbestaende-europa

https://commons.wikimedia.org/wiki/File:European_countries_by_forest_cover.jpg

Change in million ha of forest area between 1990 and 2019:

https://ourworldindata.org/grapher/forest-area-km?tab=table&time=latest&country=~OWID_WRL

But the overarching question to be discussed in plenary is: What conclusions can be drawn from these changes?

But not only the area of forests has changed, also their appearance. In Austria, for example, after the end of the last ice age (about 12,000 years ago), pine and birch were the dominant tree species, around 1000 AD beech, today it is spruce (see worksheet 2.2c).

History of the forest (retreat and expansion with the ice ages), to start the topic students may watch this film on UNESCO world heritage sites:

Primeval Beech Forests: https://www.youtube.com/watch?v=u-ScUvhTLcs

Alte Buchenwälder Europas: https://www.youtube.com/watch?v=yXiGyytVs70&t=63s

The students try to find reasons and explanations for this drastic change in the forests and discuss what other changes could accompany it (for example, in terms of biodiversity, resilience, silvicultural use). Students create a flipchart on which they list possible reasons for change. They also consider what indicators or data they would need to be able to assess this.

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If you wish, you can include an optional activity on the meaningfulness of tables and diagrams. However, this discussion is not the focus of this module, but relates to the contents of module IO4 Analysing (big) data.

This session contributes to the achievement of the following learning outcomes:

- Experience in dealing with environmental socio-scientific issues involving forests
- Skills on how to explore, analyze and recognize interrelationships
- Awareness that dealing with environmental socio-scientific issues can be linked to the goals of mathematics and science education
- Examples of scaffolding connected to forest issues
- Skills on how to deal with them in an appropriate way

2.3. Forests and climate change

Duration: 45 minutes

First, the trainer gives a short input on the influence of the forest on the regional climate:

The forest has a balancing effect on the regional climate. Rain, for example, is absorbed by the forest. Some of the rain evaporates into the air, which has a lasting effect on the local microclimate, humidity and temperature. This is why the land and air in the immediate vicinity of a forest are often perceived as fresh and humid. These differences are noticeable even during a short walk in the forest: In summer it is significantly cooler in the forest, in winter warmer than in the surrounding area due to the reduced albedo. However, the forest also has an influence on the climate of its wider surroundings: on hot summer days, the cool forest air regulates the extreme heat development in the surrounding settlement areas. Due to the high evaporation capacity of the forest, the air contains far more moisture. Directly in the forest, the relative humidity is even up to 10 % higher than in the surrounding area.

Optionally, and if appropriate measuring equipment is available, an outdoor exercise can be included here: The students visit a forest near the training site, record their individual perception of the microclimate and measure temperature and humidity at the edge of the forest, within the forest and in the settlement area. They compare the values and discuss their results: What could be the reasons for the differences? Which functions of the forest are particularly addressed here? What could be the reasons for strongly deviating measurement results? (see worksheet 2.3a)

From our experience with microclimate, we can already guess that the forest also has an influence on the global climate and vice versa. There are considerable regional differences: while boreal forests warm the surrounding air due to their low albedo, tropical forests cool their region through strong evaporation and cloud formation and even have a cooling influence on the global climate due to their large expanse. In dense natural or sustainably managed forest areas, the soils are always cooler and moister than

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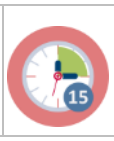
on non-forested land areas, they have a positive influence on groundwater levels and water quality, remove CO_2 from the atmosphere and store it in biomass.

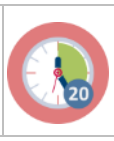
For more information refer to: https://www.climateandlandusealliance.org/scientists-statement/



Duration: 15 minutes

Through a series of exercises on forest management, the trainer familiarises the students with the scaffolding principle: while in the first exercise the framework is clearly given, in the following exercises the tasks become more and more complex and encourage the students to include more and more dimensions of the SSI forest in their considerations.

Exercise 1: The students receive data on a site: Growing area, altitude, water supply, average temperature and the profiles of two tree species. The students have to decide which tree species is better suited for this location (see worksheet 2.3b).



Duration: 20 minutes

Exercise 2: The students again receive data on a site and the site preferences of two tree species, plus information on the different yields: One tree species grows faster, can be harvested earlier and is easier to process. It therefore yields more wood that can be sold in a shorter time, but also has a higher risk of damage from storm events. The second tree species grows more slowly and yields less timber that is harder to process, but is valued for its special properties and therefore fetches a higher price per unit sold. The risk of total failure is lower with this tree species. The students should select a tree species for the site and justify their choice (see worksheet 2.3c).

Duration: 30 minutes

Exercise 3: A heavy storm knocked down a large part of the tree population. This is a protective forest, which is supposed to protect the soil and prevent rockfall and mudslides. In order to fulfil this function, the area must be reforested as quickly as possible. In groups of three students consider and discuss a number of aspects in order to make good decisions. For example they have to take into account these general conditions (see worksheet 2.3d):

- Legal framework
- Site conditions
- Economic framework

After twenty minutes of group work, the groups present and compare their chosen strategies for reforestation in plenum.

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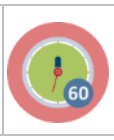
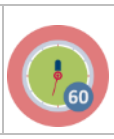


Duration: 60 minutes

Exercise 4: An avalanche went off on a popular hiking trail in the national park and severely affected the forest stand over an area of 3 hectares. The forest manager of the national park, a forest owner in the national park, a hotel owner in the national park community, a representative of WWF and a climate scientist discuss how to proceed and are confronted with many questions such as:

What are the conditions at the site? Which tree species have stood here so far? What is the terrain like (important for accessibility, management, transport)? Are there any special conditions (protected area, danger zone, ...)? Which rare or endangered animal species are found here? Which tree species would make sense at this location from today's point of view? What could this site look like in 30/50/100 years, taking climate change into account? Which tree species would then make sense from an ecological, which from an economic point of view? Which functions of the forest will have priority in the future?

The trainer divides the students into five groups. Each group takes on the role of one of the five experts and tries to find the arguments that support their position (some hints are given on worksheet 2.3e). Each group chooses a representative who takes the position of this expert in a subsequent fishbowl activity. The other students listen very actively, observe the discussion and record their perceptions. All students record their main findings from the process. These notes can later be used for assessment.



Duration: 60 minutes

Exercise 5: The students are now given the task of designing a fictitious forest of the future in small groups. Each member of the group thinks of a tree species that occurs in it:

What is the name of the tree species? What does it look like? What special adaptations to climate change does the tree species have? Which impacts of climate change can it cope with particularly well? What special function/benefit does it have for the forest and for people?

At the end of the activity 2.3, each group presents its Forest for future, for example in the form of a drawing, a poster, a text, a performance, etc.

This session contributes to the achievement of the following learning outcomes:

- Experience in dealing with environmental socio-scientific issues involving forests
- Skills on how to explore, analyze and recognize interrelationships
- Awareness about the necessity that teaching science and mathematics should also include dealing with environmental SSI
- Examples of scaffolding connected to forest issues

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- Skills on how to deal with them in an appropriate way
- Knowledge that dealing with environmental socio-scientific issues includes transversal skills like critical thinking as well as ethical, social, economic and moral issues
- Knowledge on the features of environmental socio-scientific issues and see that are different to "traditional" science and maths tasks

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3. Implementation of scaffolding and forest related SSIs in classroom

3.1. Analysis of previous forest lessons

Duration: 45 minutes

The Teacher Trainer introduces a range of scaffolding techniques to the students. The students analyse the previous lessons on the topic of the forest and try to identify the scaffolding elements.

To support this, the students receive a list of common scaffolding techniques (see worksheet 3.1).

The students first read through the materials for themselves and perhaps already make initial notes on them.

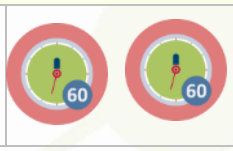
Then they discuss their findings in groups of two or three. The following questions should be considered:

- Which scaffolding elements stood out?
- What makes a good scaffold?
- Where can it be used?
- Which topics could be suitable for it?

This session contributes to the achievement of the following learning outcomes:

- Knowledge on the features of environmental socio-scientific issues and see that they are different to "traditional" science and math's tasks
- Examples of scaffolding connected to forest issues

3.2. Development of SSI lessons based on forest issues



Duration: 120 minutes + 60 minutes of homework

The intention of this activity is to let teacher students plan their own lesson using scaffolding methods.

The teacher students first have a look at the topic pool resulting from Activity 1.2 and give a vote for their preferred topic. For the topic that gets the most votes, the students should work out a scaffold in groups of two. First, consider where suitable data material for the content to be taught could be found. The research and preparation of the data material should be done by the students as homework.

The teacher trainer selects three curriculum objectives that match the content. He presents them to the students in the following practice session. Each pair is now allowed to choose a curriculum objective and thinks about how the chosen topic and the curriculum objective can be linked and how the scaffold should be built up.

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Using the data material prepared in the homework assignment, the students now plan their lesson. Each group tests the lesson setting of another group and provides feedback.

If several working groups have chosen the same curriculum objective, it is quite interesting and instructive for all participants to see how differently the task can be solved.

The worked out lesson settings later can be used for assignment.

At the end, the entire module is reflected once again together:

What do the students find easy, what difficult?

Which elements will they incorporate into their teaching in the future?

Where do they still feel insecure and need further support?

This session contributes to the achievement of the following learning outcomes:

- Experience in dealing with environmental socio-scientific issues involving forests
- Skills on how to deal with Scaffolding techniques in an appropriate way
- Knowledge that dealing with environmental socio-scientific issues includes transversal skills like critical thinking as well as ethical, social, economic and moral issues

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Materials and resources

Presentation for teacher educator

Worksheets and readings

Access to computers for internet research and collaborative work

Granularity

- In activity 1.1 skip the exercise "Forest quiz"
- In activity 1.2 students do the collection of material in exercise "Forest tales" as a homework
- Skip the calculations about changes in forest areas in activity 2.2 or let the students do them as a homework
- Skip the measuring exercise in activity 2.3
- Skip exercise 5 in activity 2.3

References

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Stoltenberg, U. (2009): Mensch und Wald. Theorie und Praxis einer Bildung für eine nachhaltige Entwicklung am Beispiel des Themenfelds Wald. München: Oekom. ISBN: 978-3-86581-126-4

Walter, H. & Breckle, S.W. (1999): Vegetation und Klimazonen der Erde. 7. Auflage. Ulmer. ISBN 978-3-662-59899-3.

Further readings

European Commission: Forest. https://forest.jrc.ec.europa.eu/en/

Global Change Data Lab: Our World in Data. https://ourworldindata.org/grapher/forest-area-km?tab=table&time=latest&country=~OWID_WRL

Let's talk science: https://letstalkscience.ca/

ScienceDaily.com: Your source for the latest research news. https://www.sciencedaily.com/

Society for Science & the Public: ScienceNews. https://www.sciencenews.org/

WWF – World Wide Fund for Nature: Forest news.

https://wwf.panda.org/discover/our_focus/forests_practice/forest_publications_news_and_reports/

ZEIT online: Waldwoche (only available in German): https://www.zeit.de/serie/waldwoche

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Assessment

Assessment methods
Individual portfolio of student's work, based on activities 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2.

Assessment criteria
The assessment criteria are based on the scientific content (learning dimension) and the pedagogical aspects (teaching dimension)

LEARNING Dimension
Students should be able to

- describe the most important factors that determine plant growth
- recognise the influence of climate on the forest and vice versa
- recognise the impact of forest on humankind and vice versa
- understand how many disciplines play a role in forest management and whose expertise can or must be sought
- to take part in the discussion on forest and climate change
- develop examples of scaffolding connected to forests
- recognise that dealing with environmental socio-scientific issues includes transversal skills like critical thinking as well as ethical, social, economic and moral issues

TEACHING Dimension
Students should be able to

- work on SSI in relation to forests and climate change in class
- link SSIs to the goals of mathematics and science education
- to use scaffolds to support students in class
- adapt scaffolds to age and achievement level of their students
- be aware of everyday ecological issues that are suitable as a basis for SSI teaching
- acquire basic knowledge and skills on how to deal with SSIs (e.g. identify and argue for different perspectives) in their future teaching

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