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Module Booklet for

CoRe Tool

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Content Representations as a tool for science teacher education

Background information

The content representation (CoRe) (Loughran, Mulhall & Berry, 2004) was designed to support teachers (and preservice teachers) to planning of a lesson (or series of lessons) and to reflect on the why, how, what and for who of science teaching. The CoRe is designed as a template where teachers formulate big ideas for a lesson or series of lessons, and then the student teacher reflects on eight different prompts in relation to different science big ideas (see table 1 below). A Big idea refers to the subject content that the teacher perceives as crucial for students to develop an understanding of the subject area. The first prompt “What do you intend students to learn about this idea?” creates an opportunity to unpack the scientific practice and the different Big ideas and describe the specific science content that students need to learn in order to understand the specific Big idea. Preservice teachers need to have knowledge of students´ understanding, but also a profound knowledge of the science content and the curricula. The second prompt “Why is it important for students to know this?” stimulates the preservice teachers to reflect on their knowledge of the given science topic and how this might become meaningful and relevant to the students in everyday life. The third prompt “What else do you know about this idea that you do not intend students to know yet?” requires teachers to decide on the science content that is selected to allow students to develop an understanding of the topic. This question requires a balance between teachers´ ambition make the content accessible for the students and the risk to include too much information that might cause students´ confusion. The fourth prompt “What difficulties/limitations are connected with teaching this idea?” stimulates the teachers´ reflections on potential difficulties that the students can experience when they learn a particular science subject. The fifth prompt “What is your knowledge about students’ thinking which influences your teaching of this idea?” contributes to clarifying teachers´ knowledge about teaching the given topic and how that knowledge affects their planning and implementation of their science teaching. The sixth prompt “What other factors influence your teaching of this idea?” relates to teachers´ contextual knowledge of students and the school context, and how the contextual knowledge is integrated with the pedagogical decisions in relation to e.g., cultural and religious considerations; the location of the school; school resources; timing of school events such as camps, etc. The seventh prompt “What teaching procedures will you use and what are the particular reasons for using these to engage with this idea?” emphasizes student teachers’ reflection on what particular teaching procedures that are used and the reason for their use in relation to the science Big idea. The eighth prompt, “What specific ways do you have of ascertaining students’ understanding or confusion?" supports the teachers´ reflection on how they can evaluate students' understanding and progress

How coherent science instruction is linked to the CoRe

The CoRe is a holistic reflection and planning tool to capture and develop student teachers´ Pedagogical Content Knowledge (PCK) (Shulman, 1986, 1987) for a particular science topic. The CoRe requires the preservice teacher to clarify and unpack which learning goals will be addressed. Working with the CoRe as a reflective tool has the potential of helping student teachers conceptualise their professional knowledge and make explicit the different dimensions of, and links between, knowledge of content, teaching, and learning about a particular topic (Nilsson & Loughran, 2013). Further, CoRe design prior to teaching episodes raises student teachers' awareness of teaching issues around certain content and engages them in reflection and decision-making that they enact in the classroom. The CoRe tool can be integrated into both subject-specific courses as well as courses in science education and more general education courses. In order to provide coherence in the teacher education program, the CoRe could be a perfect tool to link different content and education courses. In relation to the STEP-C model below, see Figure 1 (Nordine et. al., 2021), the CoRe can be viewed as a tool to connect the university context with the school practice and provide opportunities for student teachers to reflect on how the intended coherent science curriculum is enacted in a school context to stimulate students' learning of a particular science topic (or Big Idea).

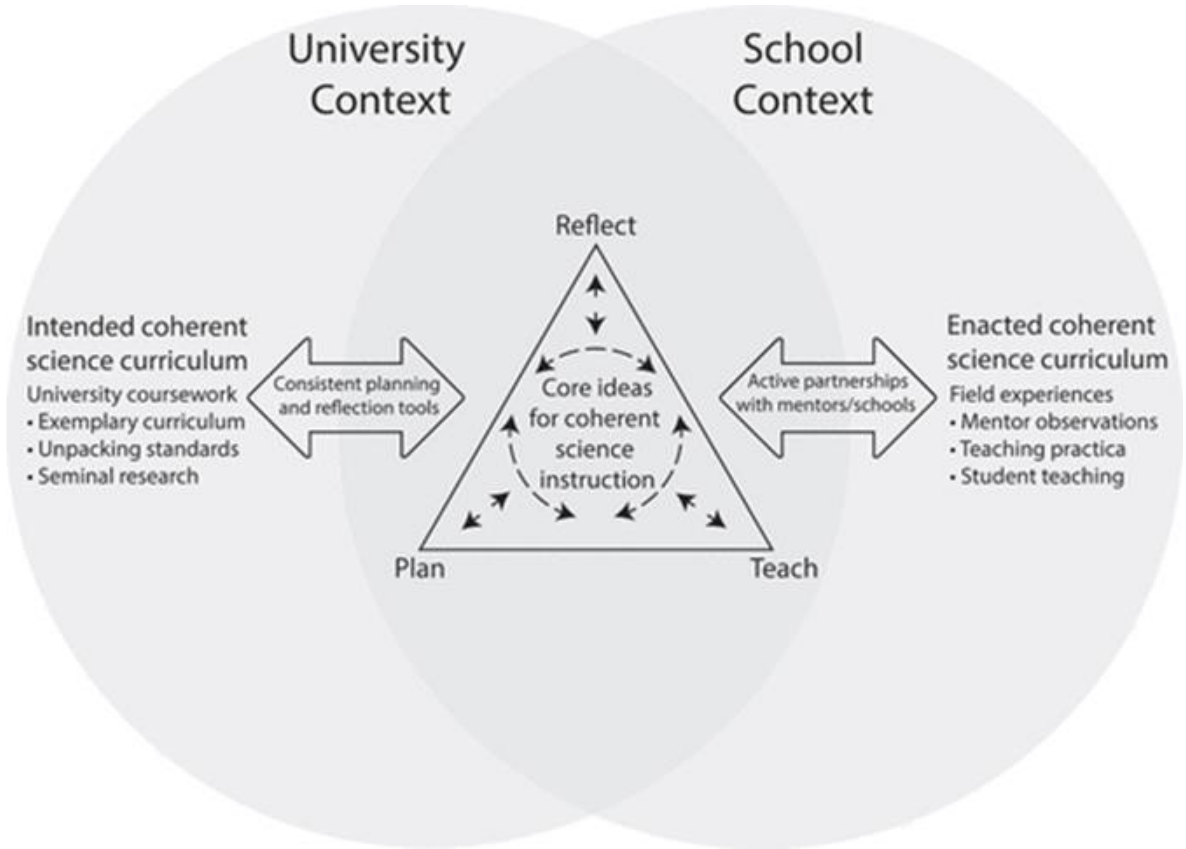

Figure 1. The Science Teacher Education Programmatic Coherence (STEP-C) model

Possible Integration into the Teacher Education Curriculum

The CoRe as a tool for stimulating reflection and capturing student teachers' development of PCK has been used in several teacher education programs all over the world. Researchers have discovered that completing a CoRe can be challenging and student teachers' lack of classroom experience might be a limiting factor (Hume & Berry, 2012; Nilsson & Karlsson, 2019). However, it is argued in research that the CoRe tool offers the most useful technique devised to date in science education research for eliciting and recording the PCK directly from (student) teachers.

The section Suggested activities for introducing the CoRe tool presents a suggestion of how to implement the CoRe tool in a science course module.

Student teachers’ challenges in using the CoRe tool

As student teachers have limited experiences of teaching science, some of the prompts can be challenging. One example is the fifth prompt “What is your knowledge about students’ thinking which influences your teaching of this idea?” where student teachers often claim that their limited experience of how students learn a particular content, limits them to respond to this prompt. Further, the sixth prompt “What other factors influence your teaching of this idea?” requires contextual knowledge of students and the school context, and how the contextual knowledge is integrated with the pedagogical decisions. For student teachers that have a limited teaching experience, this prompt is challenging. Concerning the formulation of Big ideas, student teachers with weak content knowledge have difficulties in formulating Big ideas for different science topics. As a Big idea refers to the content that the teacher perceives as crucial for students to understand in order to develop an understanding of the subject area, student teachers’ own understanding of the content is crucial. To meet these challenges, lectures and seminars should be held that promote student teachers’ knowledge in these areas. In the section Suggested activities for introducing the CoRe tool some activities are suggested regarding students’ misconceptions, language in the science classroom and how to use productive questions.

Evaluation of preservice teachers’ CoRes

Since Shulman (1986) introduced the concept of PCK it has been used as a theoretical as well as a methodological framework for describing teacher knowledge of teaching a particular content in particular ways with the ambition of enhanced student understanding. As the CoRe was initially developed to capture teachers’ PCK for a particular topic, the CoRe can be used both to develop and evaluate student teachers’ PCK during teacher education. A completed CoRe together with a video-recorded classroom teaching based on the CoRe can be used to evaluate student teachers’ PCK, or foundations of PCK, for the teaching of a particular topic (Nilsson & Loughran, 2019). Below, features of how to use the CoRe tool for reflecting on teaching a particular science topic are described.

Initial Questions of each CoRe prompt	PCK issue the CoRe prompt refers to	Information sources and strategies for CoRe design
Big Ideas	Refers to the subject content that the teacher perceives as crucial for students to develop an understanding of the subject area. There is no set number of Big ideas, but it usually tends to be between 3–6 Too few big ideas suggest that too much can be included in a single Big idea; too many Big ideas suggest that the topic was split into too small units without context. Big ideas are formulated as claims e.g., "Plants produce food" or "Plants make their food through photosynthesis" not "Plants as food producers" or "Photosynthesis and plants"	Teaching experience Curricula and syllabi, lecture plans Textbooks Web-based resources National tests Research articles First, brainstorm all possible concepts that describes the theme - write each concept on a separate piece of paper. Then organize concepts in groups with a common theme – around 4–8. The common theme of each group forms the basis of a Big idea.
What do you intend the students to learn about this idea?	This prompt is the starting point for unpacking the various Big ideas. The question describes the specific content that students need to learn in order to gain an understanding of the Big ideas. It requires teachers to know what their students can achieve.	• Teaching experience • Syllabi, lesson plans • Textbooks and • Web-based resources • National tests *Use information from brainstorming i.e., concepts and knowledge that make up Big Ideas.*
Why is it important for the students to know this?	Successful teachers build on their experience and knowledge of the given topic with what they know is relevant to students' everyday lives so that they can create meaningful ways to encourage students to understand the essence of the ideas/concepts at hand. In addition, teachers start from what motivates and interests students. Often it is related to the goals and knowledge requirements of the syllabus, i.e., such concepts that must be mastered before students can link to new concepts.	• Teaching experience • Curricula, syllabi and lesson plans • Textbooks, and web-based resources on different teaching content *Examine the knowledge requirements at different levels for ideas about likely future directions*

What else do you might know about this idea (which you do not intend the students to know yet)?	This question requires teachers to make decisions about what content to include and exclude in order for students to understand the topic/theme. This requires a balance between simplifying the content to increase understanding but still preserving the complexity of the concept. Experienced teachers know that perceived difficulties and/or unnecessary confusion can impair students' learning, e.g., when to introduce abstract ideas such as particles when learning about the properties of the material.	• Teaching experience • Curricula, syllabi and lesson plans • Textbooks and • Web-based resources on different teaching content • National tests *Examine the knowledge requirements in the curricula to decide on what content that is relevant for these particular students*
What difficulties/limitations are connected with teaching this idea?	Teachers here get to develop and respond to the insights they developed about potential difficulties when teaching a particular subject. For this question, there is support in research on alternative perceptions/misconceptions and limitations in methods that use models and analogies to promote understanding or explain phenomena. Experienced teachers use this knowledge and information to shape the way in which they teach specific concepts and topics.	• Teaching experience • Textbooks and • Web-based resources • Scientific research articles
What is your knowledge about students' thinking which influences your teaching of this idea?	This prompt helps to clarify what teachers have paid attention to through their experience of teaching the given subject and how that knowledge influences their thinking about teaching. They plan their teaching based on what they have learned about students' common perceptions of the subject and how students typically respond to the teaching of the subject (including interest).	• Teaching experience • Textbooks and • Web-based resources Scientific research articles
What other factors influence your teaching of this idea?	This prompt makes teachers' contextual knowledge of students visible as well as their general pedagogical knowledge to show how these factors can influence how they shape their teaching, e.g., cultural and religious considerations; the location of the school; school resources; timing of school events such as camps, etc.	• Teaching experience • Textbooks and • Web-based resources • Scientific research articles
What teaching procedures will you use and what are the particular	Teachers choose which methods to use on the basis of promoting various aspects of learning. An activity is often	• Teaching experience • Textbooks and

reasons for using these to engage with this idea?	used to start a lesson. Choosing appropriate methods for given teaching and learning conditions is an important aspect of a teacher´s PCK. It requires expertise to choose methods appropriate to the intended learning outcomes, to know how and when to use them, and why. Teachers should be able to adapt their teaching methods to meet the contextual needs of the time.	• Web-based resources • Scientific research articles, e.g. about PCK and the use of CoRes
What specific ways do you have of ascertaining students' understanding or confusion around this idea?	Successful teachers constantly capture students' understanding and progress (both formally and informally). This prompt makes visible how teachers do this in order to obtain information about how effective their teaching has been, as well as to give input to their future teaching practice, adjust their thinking about the same or similar teaching situations in the future.	• Teaching experience • Textbooks and • Web-based resources • Scientific research articles, e.g., on PCK and the use of CoRes

Suggested Activities for Introduction

When introducing the CoRe for student teachers it is important to provide a basis for the context in which the CoRe was developed (i.e., Loughran, Mulhall & Berry, 2004). Therefore, the teacher educator should provide student teachers with relevant research connected to PCK and CoRe design (e.g., Hume & Berry, 2011, 2013; Loughran, Mulhall & Berry, 2004; Nilsson & Loughran, 2012; Nilsson & Karlsson, 2019).

Further, it is important to introduce the main ideas of Pedagogical Content Knowledge, how the framework was introduced by Shulman in 1986 and how it has continued to develop through international research during almost 40 years. In the introducing lecture, the student teachers should be challenged to discuss questions such as “what knowledge is needed for teachers to teach a particular content in order to promote students’ learning?”, “what components of knowledge constitute the complex body of knowledge that is unique to teachers?” “what makes a good teacher”, etc. As such, the student teachers are stimulated to reflect on what knowledge is needed to promote students´ understanding (i.e., PCK).

Then, after this introduction, each prompt in the CoRe needs to be discussed. For this part, the teacher educator can use the document “Unpacking the CoRe prompts”. During this activity, the student teachers have the possibility to ask questions about the different prompts and the formulation of Big Ideas.

Finally, you, as a teacher educator, ask the student teachers to choose a science content from the curricula and formulate a theme in relation to the students being taught. Then, student teachers work in groups through a blank CoRe sheet and discuss the prompt and complete the CoRe. This activity normally needs a good amount of time for student teachers to work through a theme, 3-4 Big Ideas and the eight prompts.

Then, to end, the different groups of student teachers share their reflections in their CoRe in a whole class activity. During the discussions, you, as a teacher educator, challenge the student teachers’ ideas of what was difficult or easy when completing the CoRe etc. In parallel with the sessions below the student teachers are taking courses on biology, chemistry, physics, and technology to achieve the content knowledge necessary for science teaching.

Below is a systematic table of how it might look like throughout a whole science course:

Session	Phase	Organization	Materials	Activity	Student preparation
1	Introduc-tion to the pro-ject	Lecture Approx. 60 min	Slides for Introduction Instructions for writing the reflecting paper on the project in the end of the course	Introduction of the project and the units in the module, and how these are aligned in relation to PCK and teacher training at school in the end of the semester.	Student teachers read the local instructions on teacher training at schools.
2	Introduc-tion of CoRe	Lecture Approx. 60 min	Slides for Introduction	Introduction of CoRe	Student teachers read: The vignettes on CoRe. Student teacher watch the video: CoRe-presentation - short version (without "Unpacking the CoRe-prompts) The article: Nilsson & Elm (2017). Capturing and Developing Early Childhood Teachers' Science Pedagogical Content Knowledge Through CoRes, *Journal of Science Teacher Education, 28*(5).
		Work in small groups Approx. 60 min	The CoRe template	The students work in small group to identify big ideas in a CoRe on a science theme decided by the teacher.	
	School visit	Two days visit at the student's teacher training school		The student teachers visit the schools they are doing their teacher training on. During the visit they decide together with their teacher trainer on a theme in science to work with in the project.	

3	Work-shop on CoRe	Lecture Approx. 45 min	CoRe template, curriculum/syllab uses, textbooks	Introducing the workshop and how to work with the CoRe in small interdisciplinary groups.	Student teacher watch the video: CoRe-presentation - long version (with "Unpacking the CoRe-prompts) Student teachers have together with their teacher trainer at school decided on a theme in science to work with in the project. Student teachers read the vignette on CoRe. Student teachers prepare themselves by studying the content of their theme to assure they have enough content knowledge.
		Interdiscipli-nary work in groups on creating individual CoRe:s Approx. 90 min	CoRe template, curriculum/syllab uses textbooks	The students process and discuss each other's CoRes on the Big Ideas of the theme and how to structure the content for students according to the CoRe prompts 1, 2 and 3.	
4	Language in the science classroom	Lecture Approx. 60 min	Slides for Introduction	Discussions on the role of language in the science classroom and what might be important to highlight in relation to students learning of science concepts in the CoRe (see prompt 4 and 5)	Student teachers read and summarize the content in the articles below: Karlsson, Nygård Larsson, & Jakobsson, A. (2016). Flerspråkighet som en resurs i NO-klassrummet [Multilingualism as a resource in the science classroom]. *Pedagogisk Forskning i Sverige, 21*(1–2), 30–55. Andersson, Löfgren & Tibell (2020). What's in the body? Children's annotated drawings, *Journal of Biological Education, 54*(2), 176-190
		Discussion whole group Approx. 45 min	The article: Multilingualism as a resource in the science classroom	Student teachers present and discuss their reflections on the role of language in the science classroom	

	Students' misconceptions	Lecture Approx. 60 min	Slides for instruction	Introduction on how to find out and take into account students' misconceptions in relation to teaching of science and the specific content in the CoRe:s (see prompt 4 and 5).	
4		Discussion whole group Approx. 30 min	The article: What's in the body? Children's annotated drawings	The student teachers present and discuss their reflections on students' misconceptions regarding the article: What's in the body? Children's annotated drawings	
		Lecture Approx. 45 min	Slides for instruction Database ERIC	Introduction of the task in which student teachers search and present students' misconceptions in relation to the theme in their CoRe. Introduction on how to search for research articles in the database ERIC (incl. search technology).	
		Work in small groups (thematically) Approx. 45 min	Database search on articles about students' misconceptions	The student teachers work in small groups to find research articles on students' misconceptions regarding the science theme in their CoRe:s (see prompt 4 and 5).	
5	5	Students' misconceptions – follow up	Presentations of group work - research on students' misconceptions Approx. 90 min	Oral presentations or/and Power point presentations	The student teachers present the research article regarding students' misconceptions in accordance with their theme. To be included: background, method, selection, results, implications for their teaching.

	Produc-tive questions in the science classroom	Lecture/discus-sions in whole group Approx. 45 min	Slides for Introduction	Introduction on ways to ask productive questions in the science classroom. Student teachers present and discuss their reflections on Taking the plunge - How to Teach Primary Science More Effectively.	Student teachers read and summarize the content in the chapter below: Elstgeest & Harlen (red.). Våga språnget! Om att undervisa barn i naturvetenskapliga ämnen. (1. uppl.) Almqvist & Wiksell (Eng. Taking the plunge - How to Teach Primary Science More Effectively)
		Work in small groups (thematic-cally) Approx. 45 min	CoRe template, curriculum/syllabus, textbooks	The student teachers continue their work on their CoRe:s with the aim to finalize them during this session.	
	Investi-gating students' misconceptions in a class-room context	Lecture Approx. 60 min	Slide for introduction	Introducing ways of gain knowledge of students' misconceptions in the classroom e.g., Concept cartoons.	Concept cartoons in English: https://edu.rsc.org/resources/science-concept-cartoons/4012180.article
5		Workshop Approx. 60 min	Concept cartoon template or other kind of survey to map students' misconceptions	Students create their own Concept cartoon or other survey to use when visiting their teacher training school. The aim is to gain knowledge of their own students' misconceptions of the content there are planning teach according to the CoRe.	Concept cartoons in Swedish: https://www.skolverket.se/skolutveckling/inspiration-och-stod-i-arbetet/stod-i-arbetet/concept-cartoons-i-naturvetenskap
	School visit	Two days visit at the student's teacher training school		The student teachers visit the schools they are doing their teacher training on. During the visit they conduct a survey on students' misconceptions with a group of students.	Preparation of a survey e.g., Concept cartoons

7	Preparation for teacher training at school	Seminar Approx. 90 min	Instructions for teacher training at schools. Last preparation for implementing the project on coherent science instruction with CoRe.	The student teachers present and discuss their results of the survey of students' misconceptions by Concepts cartoons or other surveys. They refine/revise their CoRe with specific focus on prompts 4-8.	Student teachers read and reflect on the instructions for the teacher training at schools.
	Teacher training at schools for 4 weeks			The student teacher implements the planned teaching according to the CoRe. The student teacher reflect/discuss the results with the teacher trainer at school.	The student teachers are writing reflection logs during their teacher training at schools.
8	Follow up on the teacher training at school	Seminar Approx. 90 min	Prepared questions to reflect on. Instructions for writing the reflecting paper on the project.	The student teachers present, reflect, and discuss their experiences from their teacher training and the implementation of their planned teaching. Instructions/preparations for writing a reflection paper on the project.	

9	Follow up on the implemented project - CoRe	Seminar Approx. 90 min	Prepared questions to reflect on.	Student teachers reflect and discuss on their experiences from using CoRe in their planning and teaching of science content.	
10	Feedback on the reflection paper	Seminar Approx. 90 min		Student teachers reflect, discuss and get feedback on the reflection paper.	Review of the guidelines for academic writing
11	Hand in the reflection paper				

Instructor Materials

Blank CoRe template

Theme	Big idea 1	Big idea 2	Big idea 3
What do you intend the students to learn about this Big idea?			
Why is it important for the students to know this?			
What else do you know about this Big idea (that you do not intend the students to know yet)?			
What difficulties/limitations are connected with teaching this Big idea?			
What is your knowledge about students' thinking which influences your teaching of this Big idea?			
What other factors influence your teaching of this Big idea?			
What teaching procedures will you use and what are the particular reasons for using these to engage with this Big idea?			
What specific ways do you have of ascertaining students´ understanding or confusion around this Big idea?			

Example of CoRes

These examples come from authentic cases where teachers have worked with CoRe in our projects over the years.

Primary School

Theme Air	**Big Idea 1** Air takes up space.	**Big Idea 2** Warm air rises while cold air sinks.	**Big Idea 3** The air is vital to life on Earth.
What do you intend the students to learn about this Big idea?	I expect students to gain an understanding that air is actually something, as well how air can be observed.	I expect students to understand the fundamental differences surrounding hot and cold air, as well as how this can be observed in everyday life.	I expect students to gain a deeper understanding of the basic properties of air, how important it is for both people and the environment. Here I also expect students to gain an understanding that air contains different gases that have different "properties".
Why is it important for the students to know this?	Students will learn about the basic properties of air and how they can be observed (central content in biology/ physics/ chemistry for grades 1–3). At the end of year 3, students should be able to give examples of the properties of air and relate to their own observations (knowledge requirements for acceptable knowledge at the end of year 3).	By discussing and illustrating air's different properties depending on, for example, temperature, this hopefully do that students gain a deeper understanding of events in everyday life linked to air. Students will learn about the basic properties of air and how they can be observed (central content in biology/physics/chemistry for grades 1–3). At the end of year 3, students should be able to give examples of the properties of air and relate to their own observations (knowledge requirements for acceptable knowledge at the end of year 3).	By briefly touching on similar parts about the central content of grades 4–6 in biology, chemistry and physics, the students are given the conditions for further interest and curiosity about air. Students will learn about the basic properties of air and how they can be observed (central content in biology/physics/chemistry for grades 1–3). The basic properties of air and how they can be observed are important in order to obtain the right conditions for further development in the natural sciences of biology, physics, chemistry and engineering.

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What else do you might know about this Big idea (which you do not intend the students to know yet)?	The exact composition of the air and its impact. Deep knowledge of atoms and molecules.	Deep understanding of atoms and molecules. *Why* winds, storms and hurricanes occur.	The names and designations of the various gases. Percentage distribution of the gases in the air. Deeper understanding of the greenhouse effect and photosynthesis.
What difficulties/limitations are connected with teaching this Big idea?	The concept of air is very abstract, it is not something you can see or clearly touch. Students may find it difficult to understand how air can be decisive for various phenomena, such as flying. There is a risk that it may become uninteresting due to the fact that it is abstract and can be difficult to understand.	Misconceptions about the abstract concept of air which can lead to their own incorrect interpretations of the concept.	That the air is so complicated, even though we can't see or touch it. Everything looks almost the same from the human eye. Some students may be ready to dive deeper into certain parts, such as the greenhouse effect, while some students still have a hard time understanding what is meant by Big Idea 1. Students mix concepts and phenomena and their meanings. For example, students may find it difficult to distinguish between greenhouse effect and elevated greenhouse effect.
What is your knowledge about students' thinking which influences your teaching of this Big idea?	That air is nothing. Abstract and difficult to grasp for students, which can lead to difficulty in progressively developing teaching.	That science in general is boring and difficult. That air is only oxygen. Need to teach in a way where I give students the conditions to look at science concepts (air) in a curious and interesting way.	That the air consists only of oxygen. Students may have difficulty understanding what is meant by gases, as gases are often linked to bombs or poison. Students believe that the greenhouse effect is dangerous.
What other factors influence your teaching of this Big idea?	Students' prior knowledge of the concept of air. Group divisions that do not work. Fights between students about the practical elements.	Should the students not understand, it easily becomes uninteresting. Failed experiments. Fears of experimentation.	Students at very different levels. Student absence creates difficulties around the practical parts.

What teaching procedures will you use and what are the particular reasons for using these to engage with this Big idea?	Very practical and concrete work where the students experiment and investigate different things about the properties of air. I think this provides the conditions for a curious and motivated learning environment. Active participation in laboratory work and that the students get to explore the concepts together and discuss these. Interesting film clips. Work both individually and in groups.	Cooperative rehearsal exercises to give all students the conditions to keep up with the teaching. Very practical and concrete work where the students experiment and investigate different things about the properties of air. I think this provides the conditions for a curious and motivated learning environment. Work both individually and in groups.	Cooperative rehearsal exercises to give all students the conditions to keep up with the teaching. Very practical and concrete work where the students experiment and investigate different things about group about the properties of the air. I think this provides the conditions for a curious and motivated learning environment. Interesting film clips. Work both individually and in groups.
What specific ways do you have of ascertaining students´ understanding or confusion around this Big idea?	Laboratory work and laboratory reports. Open discussion and questions.	Laboratory work and laboratory reports. Cooperative rehearsal exercises from the previous lessons. Open-up questions where it is visible if the students have learned what we have been through.	Cooperative rehearsal exercises from the previous lessons. Kahoot. Individual factual text.

Middle School

Theme The Water cycle	Big Idea 1 Water may be in various forms of aggregation (liquid, solid, gas)	Big Idea 2 Water circulates between the ground and the atmosphere (evaporation, precipitation, groundwater)	Big Idea 3 Water is exposed to various physical phenomena and processes that make it easier for us humans.
What do you intend the students to learn about this Big idea?	How simple particle models can describe the structure and movement of the water molecules in the various forms. Be able to mention the three different states of the water (solid, liquid, gas) and describe distinct differences in the form and volume between the different states. Be able to know that water can change from one state to another through the supply or discharge of energy and describe these changes in form of melting, freezing, boiling, evaporation or condensation.	How water was formed from the beginning. Why water is needed. The water's path between the soil and the atmosphere. The sun's role in the water cycle. The students will follow the water's path between sea / lake and atmosphere, as well as back to the surface of the earth and to groundwater.	How, among other things, the water tower works, what underlying principles that make it possible for the water to get to our home cranes. Students will understand how gravity affects water and how we use that knowledge. They will also superficially understand other technical innovations that are related to water; what physical phenomena are behind the development of this technological innovation.
Why is it important for the students to know this?	To understand the water cycle, students must understand the water's phase changes. Water is always around us. An increased understanding of their surroundings can give greater desire to explore their world and be of aesthetic value.	The students will realize how nothing could live without water; neither plants, animals nor humans. Everything contains water. Humans, plants and animals contain water. The students will also meet on a mindset of sustainable development during the course of work, where we will shed light on the importance of water and how we can best maintain it.	In the other Big Ideas, the students have been introduced to the structure and circulation of the water. Students now get to know the physical moments that show the students how the water is utilized in technological innovations; which made life easier for us people.

	It also works as a gateway / preparation for future studies, as higher grade courses impose higher demands on particle thinking and understanding of atomic models.		They will also get an insight into the availability of water in the world and the technology behind.
What else do you might know about this Big idea (which you do not intend the students to know yet)?	The atomic structure of oxygen and hydrogen with protons, neutrons and electrons. The bonds between water molecules are called hydrogen bonds. Water can go straight from solid to gas and vice versa (sublimation and deposition). That entropy is involved in how much water changes state.	Different types of precipitation, cold front and hot front and how these phenomena are included in the cycle. Ecosystem of which the water is included. Other substances that may be in precipitation (carbonic acid, low or high pH value, calcium)	Calculation of pressure in different kind of events using formulas.
What difficulties/limitations are connected with teaching this Big idea?	Particle models can be experienced as difficult to understand and spaced from reality. Student's picture of reality is usually dominated by a macro-level. The significance of the micron level can therefore be difficult to motivate. Students will construct many own investigations. Without sufficient support and good structure, the studies can only lead to superficial learning.	The water that we are using now, may have been drunk by dinosaurs. A truth with modification! That groundwater does not really come from ground but comes from the atmosphere. An invisible cycle that may be difficult for students to understand.	In order to understand how the water tower works, some understanding of certain physical phenomena needs to be understood. If you do not understand that it may affect the teaching.
What is your knowledge about students' thinking which influences your teaching of this Big idea?	It is not uncommon that atoms and molecules are wrongly given the	The students have so far met the simple water cycle and have not gone into	Students can have a misleading picture of how water is brought to our home, that it is "pumped out". This misconception is

	same properties as the subject they build at the macro level. Confusion of the terms melting, freezing, boiling, evaporation or condensation. Misconception that water disappears or is created when it changes phase. Misconception that water only boils at 100 ℃ and that evaporation only occurs when it is hot. Misconception that bubbles in boiling water are air.	details about how the water molecules move in a complex system.	common and is something that education has to meet.
What other factors influence your teaching of this Big idea?	Students often have a limited perception of things at the micro level. This can lead to a feeling of “not capable of understanding”, which may affect their motivation. Many of the curriculum skills and knowledge requirements require good advancement and verbal ability. Silent students can therefore be disadvantaged without adjustment and variation.	Because this part of the work is based on an earlier understanding of the microstructure of water, as well as how a water molecule moves in different temperature conditions, an understanding of the various phases of water (solid, liquid and gas) is required.	Students´ motivation can affect their learning - as well as the interaction among the students and the classroom environment. Therefore it´s important to keep this in mind and plan for positive factors as well as prevent negative factors for a good learning climate.
What teaching procedures will you use and what are the particular reasons for using these to engage with this Big idea?	We will use a digital air humidity sensor to visualize the water vapor's existence. The sensor will be connected to a closed container with	Teaching for this section is based on giving students an understanding of the water cycle. We will be using various films to explain that cycle.	The principle of water tower is based on the influence of the gravity. By using a pressure sensor that is connected to a datalogger, students will be able to see a

	a small amount of water inside. We will heat up the water until it boils. We use this method to make the invisible visible - that the water does not disappear when it is evaporated just because we cannot see it.	The digital method will not be used much during this section because we realise that in this case it is better to do different analog experiments to visualize scientific issues.	change in pressure depending on mass and gravity. The experiment can provide students with a deeper understanding of how the water tower works.
What specific ways do you have of ascertaining students´ understanding or confusion around this Big idea?	Water in gaseous form is invisible to our eyes. An air humidity sensor will therefore be used to visualize the presence and phase change of water from liquid to gas. It gives students an opportunity to understand (and in front of everything to graphically see) the change that happens. A limiting factor may be that reading the result requires a certain mathematical ability to read graphs and tables. This might limit the use digital tools.	That the digital tool does not provide a complete picture of how the water moves in a cycle. Or that the image of the cycle becomes to simplified and will therefore not lead to understanding of the total concept of the water cycle.	Digital tools can provide students with a further learning opportunity and / or provide an even clearer picture of how physical phenomena are used in everyday life.

Theme Photosynthesis	**Big idea 1** Photosynthesis is one of the prerequisites for life on Earth.	**Big idea 2** Photosynthesis is a process in which plants can produce their own food.	**Big idea 3** Photosynthesis occurs in the chloroplasts of the leaves of the green plants.
What do you intend the students to learn about this Big idea?	All living organisms on Earth need both chemical energy and oxygen. Both products come from the process of photosynthesis.	The plants can harness the sun's energy and store it in leaves, stem, roots and fruits. Carbon dioxide, water and energy from the sun create chemical energy in the form of sugar (glucose).	The plants take in carbon dioxide via the cleavage openings on the underside of the leaves. Water is transported through the roots of the plant to all the cells of the plant. In the chloroplasts of the plant, photosynthesis occurs.
Why is it important for the students to know this?	An increased knowledge of photosynthesis is likely to lead to an increased sense of use and conscious positions for both our global and our local environment. Herein lies not only the carbon dioxide/oxygen balance, but also an understanding of the impact of photosynthesis on the function of ecosystems and the biomass produced in them.	Partly to understand the ability of plants to utilize the sun's light energy and store it as chemical energy (sugar), but also to thereby understand the place of plants in ecosystems as producers and as food (potential energy) for other organisms.	To understand that photosynthesis only occurs in the green plants and that they can "capture" and convert the otherwise inaccessible light energy into chemical energy. These cell organelles (the chloroplasts) are unique to the plants, and they are a prerequisite for the chemical process in which carbon dioxide, water and light energy from the sun create sugar and the waste product oxygen.
What else do you might know about this Big idea (which you do not intend the students to know yet)?	Do not connect in detail too many other systems that are prerequisites for life on Earth such as the ozone layer and the water cycle.	How energy flows in the world around us and how this energy is distributed between producers, consumers and their surroundings.	Details on how the chemical energy is formed through various chemical reactions in the chloroplasts. This is described more comprehensively.
What difficul-ties/limitations are connected with teaching this Big idea?	Models and drawings (e.g., image of the gas exchange taking place through the leaves) are often simplistic representations. How should delineations be made in relation to this fact?	The difficulty for the students to understand that photosynthesis occurs as storage in the plants and that, like other organisms, they must utilize the chemical energy in the cellular	There can be confusion about what "waste" means as oxygen (O_2) is not usually referred to as waste.

		respiration process to assimilate the energy.	
What is your knowledge about students' thinking which influences your teaching of this Big idea?	Students do not always have a particle and molecular understanding, which can lead to difficulties in understanding complex conditions in the remodeling and cycle of molecules.	Ideas that substances arise and disappear or that substances in a cycle are constantly in the same state. Therefore, it is important to understand "nothing disappears" both in terms of both chemical understanding (chemical reactions) and physical understanding (the energy principle).	Through previous teaching in the subject, students have an understanding that the substances oxygen, water, sugar and carbon dioxide are involved in photosynthesis. However, it is common for them not to make connections to how these substances get in and out of the plant or make connections to how the plant grows or produces sweet fruits, etc. It is important to connect in everyday teaching.
What other factors influence your teaching of this Big idea?	Students can, for religious reasons, explain the world in other ways than the accepted scientific explanation.	Important to describe the metaphor of food in the context so misconceptions can be avoided.	
What teaching procedures will you use and what are the particular reasons for using these to engage with this Big idea?	Class discussions about what is known about photosynthesis in the past to be able to take this as a starting point in teaching. Work with the project "closed system", where students in smaller groups specialize in different parts of the closed system. Through this way of working, students can specialize in different parts of the closed system, hopefully providing a depth of knowledge. In addition, everyone gets the opportunity to be involved and have a responsibility in the whole.	Group discussions: How do plants create their food? What is the connection to how the human body get energy from the food? The students make their own model of how the different constituents oxygen, carbon dioxide, sugar, solar energy and water flow in what we call photosynthesis. Students may have misconceptions that is met up through cross-group accounting. One from each group brings their model to a new group and here they present their model, compare and revise different misconceptions. The new model in the group is then described in a full group where further clarifications can be made together with classmates and the teacher.	Create variable attempts with data logger measurements. The sensors that measure oxygen content, carbon dioxide content, humidity and temperature. Measurements can be varied, for example, based on the availability of light, heat and water. This complexity and variation provide measurement data in the form of graphs that can provide opportunities to train oneself in interpreting and analyzing measurement data. Here, students first work in pairs and then two pairs meet to exchange experiences and conclusions of the photosynthesis experiments.

What specific ways do you have of ascertaining students´ understanding or confusion around this Big idea?	Students record their group discussions, and this creates the opportunity to follow all groups and students to look at both overall abilities and specific abilities in biology. Through here, strengths and misconceptions can emerge, and these can be raised with the students the next time we meet.	Pay attention to limitations in the use of symbols and models. Use a post-test using a mentometer system to see what the students have learned of the model they have been involved in creating.	Listens to what connections are made between the choice of variables and how these control the availability of carbon dioxide and oxygen in a system. A practical test situation at the end of the area, where the variable experiment is described, and the students get to solve these individually. With the help of these experiments, it is clear what the students learned based on set criteria.

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