Ref. Ares(2024)1428469 - 25/02/2024

Climademy

Co-funded by the European Union

Project: 101056066 — CLIMADEMY — ERASMUS-EDU-2021-PEX-TEACH-ACA

Deliverable D3.1

Document ID: CLIMADEMY -WP3-D3.1 – PU –v4.0

Due date of deliverable: 31/10/2023

Actual submission date: 30/11/2023

Dissemination Level		
PU	fully open (automatically posted online on the Project Results platforms)	
SEN	limited under the conditions of the Grant Agreement	X
R-UE/EU-R	RESTREINT-UE/EU-RESTRICTED, CONFIDENTIEL-UE/EU-CONFIDENTIAL, SECRET-UE/EU-SECRET under Decision 2015/444.	

Task leader for this deliverable: University of Bologna

Authors: Maria Kanakidou, Nikos Kalivitis, Dimitris Stavrou, Emily Michailidi, Athina Ginoudi, Giannis Metaxas, Thalia Tsaknia, Giorgia Bellentani, Chiara Ciliberto, Francesco Martinelli, Stefania Zampetti, Laura Riittanen, Jari Lavonen, Janina Taurinen, Katja Lauri, Suvi Lintuvaara, Olivia Levrini, Giulia Tasquier, Eleonora Barelli, Clemente Rossi

Document status		
Revision	Date	Description
V0.1	06/08/2023	1st draft – University of Bologna
V1.0	10/08/2023	Revised version from University of Crete and University of Helsinki
V1.0	31/08/2023	Revised version from all partners
V2.0	15/09/2023	Final review from University of Crete
V3.0	30/11/2023	Submitted
v4.0	25/2/2024	co-funded logo and disclaimer added and resubmitted
Reviewed	YES	

DISCLAIMER

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EACEA. Neither the European Union nor the granting authority can be held responsible for them.

This deliverable contains original, unpublished work except where clearly indicated otherwise. It builds upon the experience of the team and related work published on this topic. Acknowledgement of previously published material and others' work has been made through appropriate citation, quotation, or both. The views and opinions expressed in this publication are the authors' sole responsibility and do not necessarily reflect the views of the European Commission.

Co-funded by
the European Union

.

Contents

Executive Summary

The purpose of the deliverable D3.1, “Start-up Model for teacher training”, is drafting the educational model for teacher training. The model is mainly targeted to the local teacher trainers and is articulated in three main parts: a) Guidelines for designing and implementing teacher training activities; b) CLIMADEMY Template for Instruction activities and prototypes of activities; c) Assessment tools: further guidelines and examples.

The draft model has been built through a collaborative process among the partners and the other WPs. In particular, new educational material (WP2) has been revised or developed according to the educational model from WP3 and transformed into prototypes of teaching activities for teacher education. These activities have been implemented in the CLIMADEMY network established in WP4 and the various rounds of implementation will lead to revise and improve the WP3 model, whose delivery is foreseen for the end of the project (M36).

In the Introduction, we describe the collaborative process we implemented to develop the draft model.

The section Project Description presents the entire project. It summarizes each WP‘s key ideas and the interrelationship between the different WPs.

In section 3, Guidelines for designing and implementing teacher training activities, we illustrate the model and its articulation in terms of: *Guidelines to reconstruct scientific contents for educational purposes and teacher training, CLIMADEMY competence framework, Module’s structure and orientation for learning outcomes, Pedagogical principles and methods, and Assessment guidelines.*

In section 4, CLIMADEMY Template for Instruction activities and prototypes of activities, we report the schematic structure of a possible CLIAMADEMY activity for teacher training that implements the pedagogical model drafted so far and two examples of activity description are illustrated in detail.

In the conclusions, the plan for application and further development of the model is reported.

Annex A, Assessment tools: further guidelines and examples, contains further recommendations that can be useful to share in the training activities.

Abbreviations and acronyms

Abbreviation / Acronym	Description
SDG	Sustainable Development Goals
WP	Work Package
CLAUDI	Climate Auditorium
QEC	Quality Evaluation Committee
IPCC	Intergovernmental Panel on Climate Change

Partner short name used in this document	Full Partner Name
EA	Ellinogermaniki Agogi Scholi Pangea Savva A
FG	Fondazione Golinelli
RDPSEC	Regional Directorate of Primary and Secondary Education of Crete
UBREMEN	University of Bremen
UH	Helsingin Yliopisto (University of Helsinki)
UNIBO	University of Bologna
UOC	University of Crete

1 Introduction

The scope of this deliverable is drafting the educational model for teacher training in CLIMADEMY.

The draft model is mainly targeted to the local teacher trainers.

It aims both to contribute to providing a «pedagogical identity» to the activities carried out within CLIMADEMY and to convey the teacher trainers the message that the activities with the teachers do not have only to teach new scientific contents but also new pedagogical knowledge and methods.

This deliverable is the result of the first 18 months of work in WP3 and, according to WP3 goals, it offers guidelines for designing and implementing teacher training activities. The guidelines (section 3) include:

- recommendations to analyse or reconstruct scientific contents for educational purposes;
- a competence framework as reference to point out the general and specific goals to pursue through the activities;
- a model to structure a teaching module for teacher education and organize the learning outcomes;
- pedagogical principles to be discussed in contexts of teacher education so that secondary school teachers can implement them in their classes;
- assessment references.

The guidelines are built on results of Science education research. In order to make the research references more user-friendly, we have pointed out key-messages and elaborated examples of how the key-messages can be conveyed and discussed with trainee teachers.

Furthermore, the draft model is illustrated through the design of a template to analyse, discuss or present teaching activities. The template is then used as a tool to describe prototypes of activities that exemplify the pedagogical model (section 4).

Since assessment is always an issue for the teacher, we added an Annex (Annex A) where further assessment guidelines and examples are described in more details.

The deliverable is the result of a collaborative process that we carried out in a series of workshops, during which we shared research frameworks, examples of teacher training activities and examples of analysis of such activities.

The structure of the deliverable has been designed by UNIBO (Olivia Levrini, Clemente Rossi), but the writing of the specific sections has been carried out by: Dimitris Stavrou, Emily Michailidi (sections 3.1 and the second part of 3.4); Janina Taurinen, Katja Lauri, Laura Riuttanen (section 3.2); Eleonora Barelli, Clemente Rossi (section 3.3); Clemente Rossi, Olivia Levrini (Section 3.4, first part); Clemente Rossi, Emma D'Orto and Giulia Tasquier (Section 4); Jari Lavonen (Section 3.5 and Annex A).

Athina Ginoudi, Giannis Metaxas, Thalia Tsaknia, Giorgia Bellentani, Chiara Ciliberto, Francesco Martinelli, Stefania Zampetti actively participated in the workshops, by offering examples of activities of by providing important feedback and revisions to the document.

Maria Kanakidou, Nikos Kalivitis and Marius Dan participated in the workshops to guarantee consistency and fruitful links among the Work Packages.

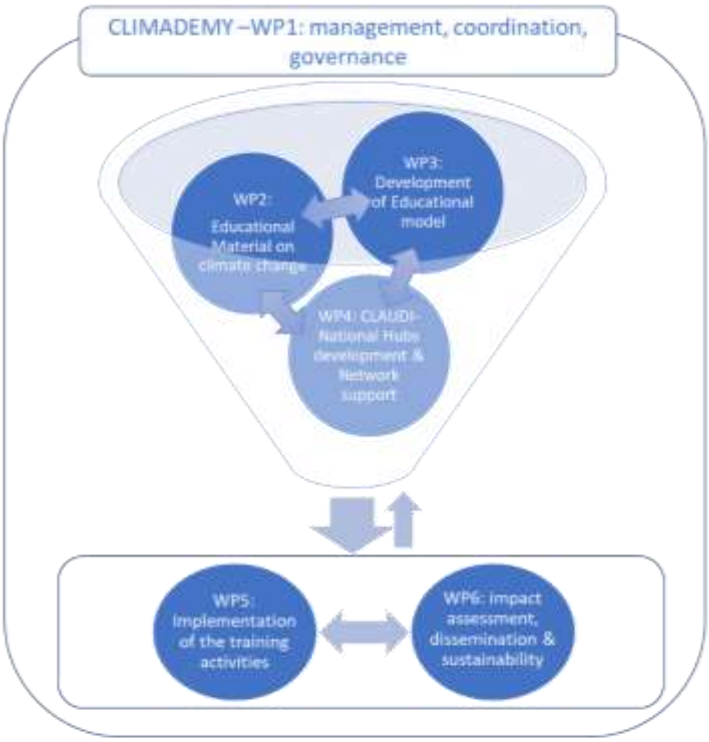
2. Project Description

This deliverable on the "**Start-up Model for teacher training**" reports the work done in WP3 of CLIMADEMY project.

The Climademy project is divided into 6 work packages, listed below.

- WP1: Project management, coordination and governance
- WP2: Educational materials on climate change
- WP3: Development of educational model for teacher training
- WP4: Establishment of a common virtual CLAUDI and National Hubs
- WP5: Implementation of the Training Activities
- WP6: Impact assessment, dissemination and sustainability

In WP1 the project coordination and management bodies are established, in order to ensure the general project coordination and monitoring of progress. In WP2 educational material are collected and further developed to understand the main drivers of climate change. WP3 focuses on the development of an educational model suitable for teacher training. WP4 is concerned with the establishment of the four national hubs and the development of the virtual CLAUDI platform. The aim of WP5 is to organize the large-scale implementation of the Training Activities leading to an enhanced notion on Climate Change Education of participating teachers and eventually to their professional development. Finally, WP6 is concerned with the dissemination and sustainability of the project deliverables.



3. Guidelines for designing and implementing teacher training activities

In this section we illustrate the pedagogical model of CLIMADEMY and its articulation in recommendations to analyse or reconstruct scientific contents for educational purposes (Section 3.1), CLIMADEMY competence framework (Section 3.2) is a model that presents a suggestion on how to structure a teaching module for teacher education and how to organize the learning outcomes (Section 3.3), pedagogical principles (Section 3.4), and assessment tools (Section 3.5).

3.1 Guidelines to reconstruct scientific contents for educational purposes and to structure a module for teacher training

The first stage for designing a teaching activity is, typically, the analysis of the *scientific contents of the activity*.

CLIMADEMY adopts the Model of Educational Reconstruction (MER) (Fig. 1) as the principal reference to design new materials or to select, value, and/or elaborate on already existing materials to be used in the teacher Academy. In some teacher workshops, Educational Reconstruction for Teacher Education (ERTE) model and a modified Content Representation (CoRe) tool have been used in the design of educational materials and pedagogical approaches, because they take into account climate values and competencies in addition to knowledge. Moreover, the modified CoRe-tool considers the use of digital tools (education technology) in teaching and learning climate related issues.

The combination of the three models is used, in CLIMADEMY, to convey the following messages to both the teacher trainers and the trainees:

> *(Key message 1) When planning instruction, an equal attention should be given to the science content (values, knowledge and skills) to be learned, students' cognitive and affective variables, as well as previous experiences linked to learning the content.*

> *(Key message 2) "The content structure for instruction is somewhat more elementary (from the science point of view) but richer than the science content structure"* (Duit et al., 2012).

In the following, we first illustrate the components of the MER model and, then, we enrich this model with aspects coming from ERTE and CoRe. After the description of these research frameworks, examples of how they can be used to spark discussions with trainee teachers on the selection of the content, and how to guide an analysis of its educational value are reported.

MER has been designed and refined by German scholars (e.g. Duit et al. 2012). As it is illustrated in Fig. 1 the MER consists of three closely interrelated components.

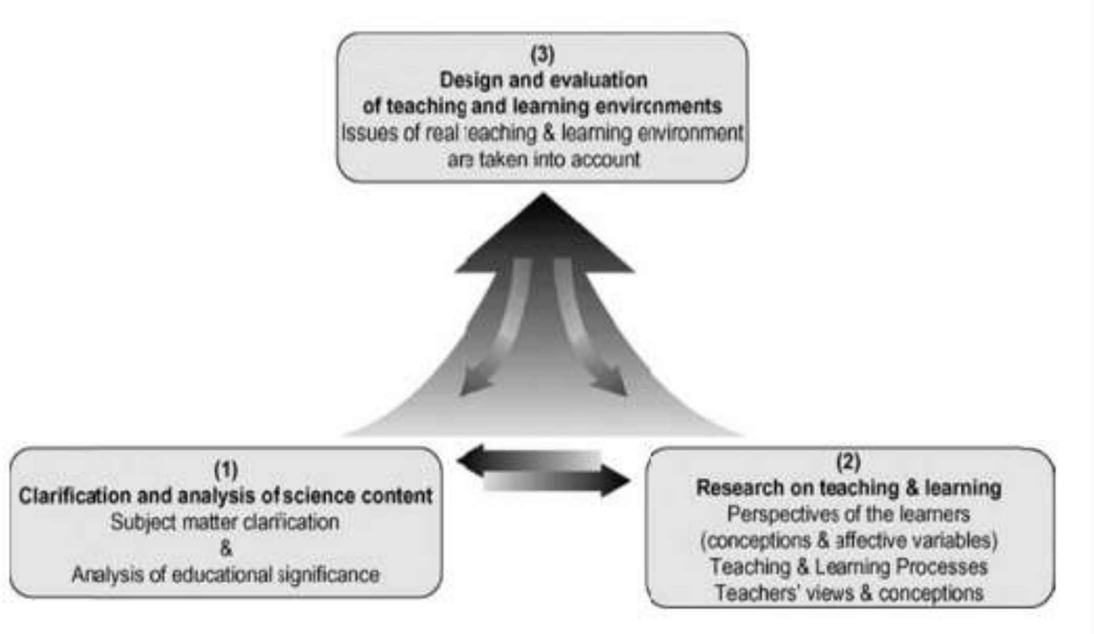


Fig. 1. Model of Educational Reconstruction (Duit et al., 2012)

Component 1 – Clarify & Analyse the science content from an educational perspective

This component orients instruction designers to assume a special take and position with respect to scientific contents of the modules and accept that contents are rich and complex enough to be "analysed", "worked" and "shaped" from many different perspectives. Specific science conceptions and the content structure reveal special nuances and meaning if they are clarified and analysed from an educational point of view. For this reason, the MER stresses the need to consider two processes as closely linked: clarification of subject matter and analysis of its educational significance. The content knowledge and structure of a certain domain have to be transformed into a content structure for instruction, *as the two structures are substantially different.* Roughly speaking, the second one has to activate cognitive resources to be approached and learned. In order to activate such a transformation, the scientific contents have to be first *elementarized* to become accessible for learners but also *enriched* with epistemological and cognitive elements that foster processes that make sense to the learners. In this process, science content issues and issues of learners' perspectives (their conceptions and views about the content as well as affective variables like their interests and science learning self-concepts) have to be taken into account and put in resonance.

Component 2 – Account for research on teaching and learning

*T*he process of clarification, analysis of science content, and the process of constructing the content structure for instruction all need to be based on empirical research on teaching and learning. It is important to take into account both the research on learners' perspectives that investigates their ideas and affective variables, and the studies on teaching that investigate orchestration processes and the role of instructional methods.

Components 3 – Design & evaluate the teaching & learning environments

The third component comprises the design of instructional materials, learning activities, and teaching and learning sequences. It also presents the learning activities that have to take under consideration all the aforementioned dimensions.

According to MER, the goal to facilitate the recognition of the educational potential of the material can be pursued by including, in the presentation of the instructional materials and learning activities, a description of:

a) the basic scientific concepts (the result of *elementarization*) of the activities;

b) their educational *enrichment* and relevance;

c) research references on students' conceptions.

The Model of Educational Reconstruction provides a theoretical framework as well as guiding principles for educational design in science education, both at research level (for which it was originally developed), and at school level. Accordingly, it can also be used as a framework for teacher education and further professional development by being appropriately transformed into a model for designing guidelines for science teachers' education. This model of Educational Reconstruction for Teacher Education (ERTE, Van Dijk & Kattmann, 2007), by analogy with the MER, aims to design effective science teacher training environments so that they are able to design their courses or implement teaching modules and activities based on the principles of constructivist teaching. The ERTE model is based on the idea that the content for teacher education needs to be 'reconstructed' for teaching taking into account empirical research on teachers' views on teaching and learning, their needs and their knowledge. In particular, in the ERTE model the following research domains are integrated in MER: (1) Guidelines for teacher education, (2) Clarification of educational design concepts, and (3) Empirical research on teacher education. These elements are strongly interrelated and they influence each other mutually.

Lougharn et al. (2008) have suggested a list of eight questions, supportive for the planning of lessons and named the collection of questions as *The Content Representation (CoRe) tool*, which could be used for structuring pedagogical content knowledge (PCK) in order to support students' learning. For the purposes of CLIMADEMY, the original CoRe tool was slightly modified for better taking into account climate education needs and use of digital tools in teaching and learning. The questions, which guide the design of lessons in this modified CoRe tool are:

1. What do students need to learn about the climate-related topic or what are the core ideas/big ideas/key concepts and models related to the topic? Should you take into account the multidisciplinary nature of the topic? Do you have specific aims related to the learning of attitudes, values and skills or the use of digital tools in learning?

2. Why is it important (meaningful and relevant) for students to learn this climate related topic (need-to-know)? Is it possible to influence students' engagement through choosing an appropriate context for learning or take into account environmental, economic, political, psychological views related to the topic? Why/Why don't students need to use digital tools in learning?

3. What else do you know about this topic - not going to teach students (the level of content)?

4. What do you know about students' everyday experiences in the area of the topic (values, knowledge and skills)? What experiences students have about the planned use of digital tools?

5. What do you know about students' conceptions/ misconceptions related to the topic and how does it affect the teaching of the topic?

6. How does context influence the teaching of this topic (student, classroom and school context)? What kind of digital tools are available at school considering your aims? Do you need to book the digital tools beforehand?

7. What kind of pedagogy you are planning to use, and how well the pedagogy suited for the topic and planned use of digital tools (knowledge-in-use)?

8. How are you going to assess student learning, including the use of digital tools (knowledge-in-use)?

In CLIMADEMY, the MER, CoRe-tool and ERTE frameworks act as research references to select the following prompt questions to be used, in the teacher training activities, to spark discussions and analyse, with the trainees, the materials and activities.

Analysis of science content:

- Which are the fundamental scientific theories and concepts involved in this topic on climate change, and where are their limitations? A climate topic always includes climate related values, attitudes, knowledge and skills. Often a climate related topic is multidisciplinary by nature and, therefore, in addition to science knowledge, also environmental, economical, societal and psychological knowledge should be taken into account. Moreover, the topic has often personal, local and global dimensions.

- What basic phenomena or basic principles; what general laws, criteria, methods, techniques, values or attitudes; what inquiry and design skills may be addressed in an exemplary way by dealing with climate change content?

- Which social implications are associated with the scientific concepts and/or the topic at issue?

- Which fields of application are affected?

- What is the relevance and significance of the content and the topic for students' future life, from a personal, social or vocational point of view?

Students' perspectives:

- What attitudes, values, subject matter knowledge and skills do students have at their disposal? Are they expression of active hope or deep anxiety toward future envisioning?

- How are the climate-related scientific concepts represented in students' perspectives?

- Which conceptions, i.e., conceptual frameworks and concepts, are used by the students?

- How do alternative frameworks and conceptions of students correspond with scientific theories and concepts?

Design of teaching & learning environments:

- What are particular cases, phenomena, situations, experiments that allow making the structure of the referring content interesting, worth questioning, accessible, and understandable for the students?

- Which are the most relevant elements of the students' conceptual framework to be respected?
- Which conceptions of students correspond with scientific concepts in such a way that they can be used for a more adequate and fruitful learning?
- What are the conditions (e.g., interests, motivations, classroom climate, power structures in classrooms) that have to be arranged in order to support learning the intended science content (to support conceptual change)?

A possible variation to the MER is constituted by the "Pedagogical Content Knowledge" approach elaborated by Shulman (1987). With respect to MER, this approach does not aim to deeply re-construct, content knowledge, but to integrate it with a special form of pedagogical knowledge:

"Pedagogical Content Knowledge is seen as a unique knowledge domain denoting the blending of content (attitudes, values, knowledge and skills) and pedagogy into an understanding of how particular topics, problems, or issues may be organised, represented, and adjusted to the diverse interests and abilities of learners." (Shulman, 1987).

3.2 CLIMADEMY competence framework

A fundamental element that must be considered in the analysis and design of teaching materials concerns the goals that the materials aim to achieve. In CLIMADEMY, following the EU competence frameworks, we use the definition of competence as "a set of knowledge, skills and attitudes" (e.g. Bianchi et al., 2022) and use this definition to frame the structure of the general and specific goals to pursue through the activities.

In CLIMADEMY we started our discussion on the competence framework from the analysis of the European sustainability competences, recently described in GreenComp framework (Bianchi et al., 2022) and developed as part of the European competence framework development. In CLIMADEMY, the GreenComp competences have been adapted to teach and learn climate related topics, especially climate change, at schools. The CLIMADEMY framework for teacher climate education has been designed by University of Helsinki, by combining the GreenComp framework with the competence framework elaborated within the ClimComp research project (https://blogs.helsinki.fi/climatecompetencies/about/). The frameworks of ClimComp project are focusing namely on climate change competencies needed in the society to mitigate climate change and adapt to the changes. The competencies were studied both among young people and climate experts in Finland (Taurinen et al, subm.; Siponen et al, subm.). The climate change competences framework, built from young people's answers in a survey, consisted of six categories; CC systems change, CC science orientation, CC leadership, CC justice and collaboration, CC implementation, and CC well-being (Taurinen et al, subm.). These have been applied to the GreenComp model (Table 1) to form a CLIMADEMY framework, utilizable by teachers in school environments.

In the GreenComp framework, four main areas of sustainability competences have been identified and each area includes three competences. The four areas with their respective competences are: 'Embodying sustainability values' (Valuing sustainability, Supporting fairness, Promoting nature); 'Embracing complexity in sustainability' (Systems thinking, Critical thinking, Problem framing); 'Envisioning sustainable futures' (Futures literacy, Adaptability, Exploratory thinking); and 'Acting for sustainability' (Political agency, Collective action, Individual initiative) (Bianchi et al., 2022).

In CLIMADEMY, we have applied them to the context of climate change teaching in schools and tried to make concrete wordings that help teachers to identify concrete learning outcomes, give examples of activities on how they can be trained in schools, and how to assess them. The result is illustrated in Fig.2.

Fig. 2. CLIMADEMY competence framework – climate change competencies for schools

The framework is articulated in four areas:

- *Values and attitudes* to motivate and engage the learner;
- *Scientific inquiry* and skills needed in scientific practices, such as working with climate data and in acquiring climate related information from different sources of information;
- *Creativity* and related abilities to design new solutions, imagining possible sustainable futures;
- *Action* competence brings competence to real life.

For each CLIMADEMY competence, the University of Helsinki researchers drafted the learning outcomes, the pedagogical methods and the assessment tools - based on the literature review and their experience in teaching climate change. The outcomes are reported in Fig. 3-6.

The articulation in the four areas stresses the extent to which climate change and its mitigation are transdisciplinary phenomena, and their understanding requires knowledge of science, technology, economics, social science, and psychology as well as related skills and values. For example, generating ideas related to reducing the amount of carbon dioxide in energy production and in the manufacturing of products, requires an understanding of issues related to society and the economy, in addition to science and technological knowledge. Moreover, associated values in this field relate to, for example, the environment, sustainability, and global justice. In addition to individual decisions, national-level decisions on measures such as legislation and taxation are needed. Even though such decisions are knowledge based, values and worldviews are the central drivers of the decisions.

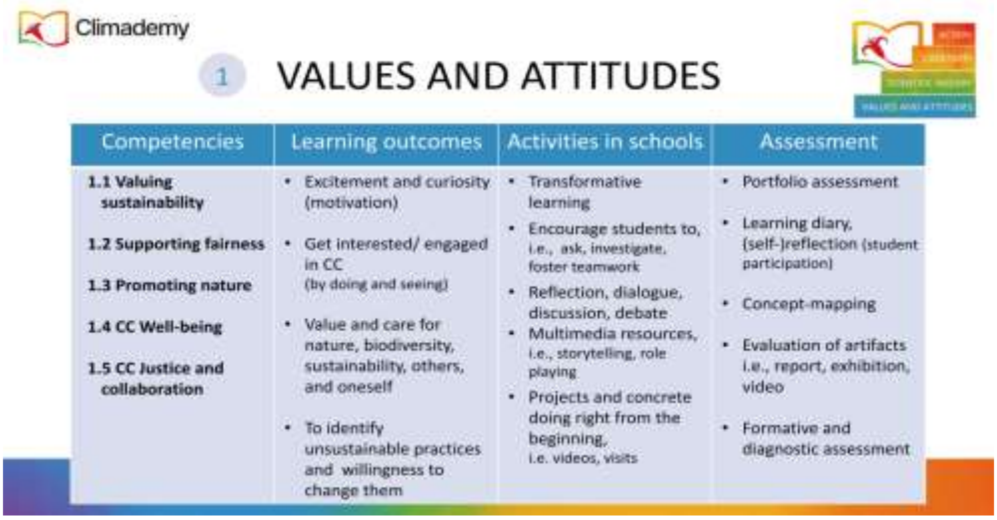


Fig.3 First step on the CLIMADEMY competence framework; Values and attitudes

The first step of the CLIMADEMY framework is called Values and attitudes (Fig. 3). Considering values and attitudes right from the start is seen as a base for building interest, motivation and expertise on the topic of climate change. This step brings together sustainability values, supporting fairness, need for collaboration and considering the well-being of nature. The learning outcome is to engage students with the topic of climate change and wake their curiosity. Before loading new information, it is important to reason the knowledge and consider the question of 'why'. Transformative learning is one way to bring this step into action. It refers to the process of acquiring new knowledge/perspectives that significantly change an individual's beliefs, values, attitudes, and behaviors. Values and attitudes can be practised in school by encouraging students to reflection, dialogue, discussions and debates. For example storytelling, role playing and utopias can be utilized as tools. Assessment can be based on for example learning diaries or teacher observing the reflections students make.

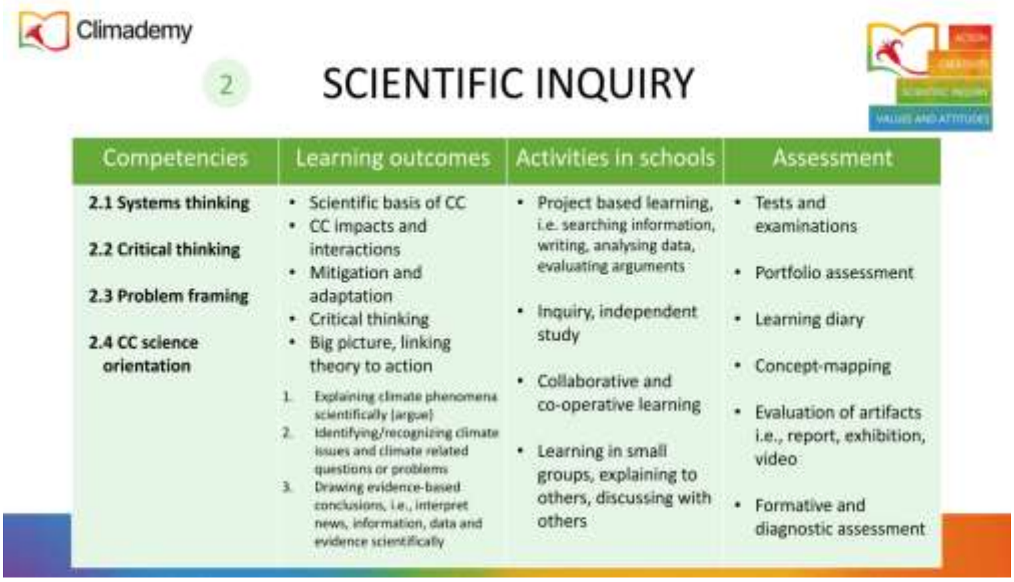
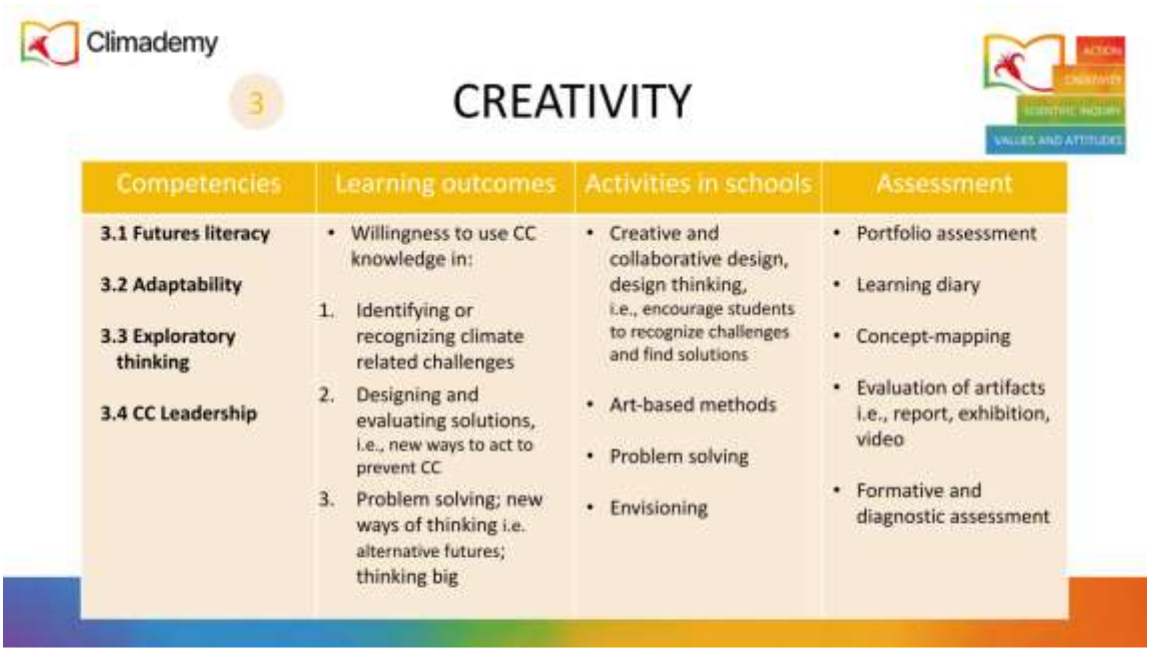


Fig.4 Second step on the CLIMADEMY competence framework; Scientific inquiry

Scientific inquiry builds the basic understanding of climate change as a scientific phenomenon (Fig. 4). Scientific tools such as critical thinking, systems thinking and problem framing are needed to get a big picture and coherent understanding of casualties related to climate change. This can be reached by traditional learning methods, like independent study and inquiry, but also collaborative learning activities, like group work and project based learning. Learning can be assessed with tests and examinations, but also discussions, portfolios, concept-mapping or by evaluation of artefacts (for example report, video, exhibition).

The competences emphasise the use of knowledge in different situations. Therefore, it is relevant to describe what is essential knowledge in the context of climate change. Although climate change is a multidisciplinary topic by nature, we list here the scientific knowledge or core ideas in this field:

- Climate science knowledge:
    - conservation of energy (first law of thermodynamics), direction of phenomena, heat transfer (second law of thermodynamics)
    - how climate system works and what are interactions in the system
    - influence of greenhouse gases and aerosols to climate and origins of them
    - how production of energy, materials and objects and traffic influences climate and water cycles
    - mechanism, reasons and causes of climate change
    - strategies for climate change mitigation and adaptation in different levels: personal – local - global
    - economic, social science, psychology views to climate change mitigation
- Knowledge about climate research and outcomes:
    - nature of climate research and origins of climate related knowledge
    - nature of climate knowledge and models



Competencies	Learning outcomes	Activities in schools	Assessment
3.1 Futures literacy 3.2 Adaptability 3.3 Exploratory thinking 3.4 CC Leadership	• Willingness to use CC knowledge in: 1. Identifying or recognizing climate related challenges 2. Designing and evaluating solutions, i.e., new ways to act to prevent CC 3. Problem solving; new ways of thinking i.e. alternative futures; thinking big	• Creative and collaborative design, design thinking, i.e., encourage students to recognize challenges and find solutions • Art-based methods • Problem solving • Envisioning	• Portfolio assessment • Learning diary • Concept-mapping • Evaluation of artifacts i.e., report, exhibition, video • Formative and diagnostic assessment

Fig.5 Third step on the CLIMADEMY competence framework; Creativity

The third step is called Creativity (Fig. 5). After building the value base, motivation and understanding of the scientific background, one can start to embrace creativity to connect things and find new solutions. In this competence the aim is to start looking outside the box and direct the thinking towards solutions. The GreenComp and ClimComp competences applied here are considering the futures literacy, adaptability, exploratory thinking and leadership. The leadership here refers to orientation to find solutions and being ambitious and bold in creating ideas in collaboration with others: to think about, for example, one's utopias and ways to make them happen, to support others' ideas and do collaboration. The learning outcomes are that one is willing to use the previous knowledge and build new ideas on top of it and to identify climate change related challenges and evaluate new solutions. Art-based methods are especially suitable for developing the competence of Creativity as these methods support free and creative outcomes and ways of executing.

Climademy

4 ACTION

Competencies	Learning outcomes	Activities in schools	Assessment
4.1 Political agency **4.2 Collective action** **4.3 IndividuaL initiative** **4.4 CC Implementation** **4.5 CC Justice and collaboration** **4.6 CC Well-being**	• To plan and conduct concrete actions and evaluate them • To know decision-making structures • To identify own potential and limits and to take care of own well-being • To communicate and co-operate with others	• Project-based learning • Collaborative and co-operative learning • Collaboration with society, project management, group leadership • Hands-on doing, concrete outcomes, i.e., projects, collaborative work	• Portfolio assessment • Learning diary • Concept mapping • Evaluation of artifacts, i.e., report, exhibition, video • Formative and diagnostic assessment

Fig.6 Fourth step on the CLIMADEMY competence framework; Action

Climate action competence builds on top of the other three steps: based on strong value-base, scientific understanding of climate change and creativity to design new solutions, effective climate action can be implemented (Fig. 6). Climate action competence includes ability to conduct both individual and collective action for climate change mitigation and adaptation. Learning outcomes include understanding of and engagement in political agency as well as your own potential and well-being. This can be practised in schools for example via project-based learning and community projects in collaboration with the society. Important for developing Action competence is to enable hands-on doing for the students, so that their projects or collaborative work has some concrete outcomes.

In the teacher training activities of the CLIMADEMY hubs, these tables are suggested to be used, together with the check list resulting from MER and CoRe, to brainstorm and share the general and specific goals of the activities.

The assessment tools for sustainability competencies are described in Section 3.5 and in Annex A. There, we introduce approaches and tools for assessing students' key-climate competences and for assessment of students' learning process. The authors of the document recommend that versatile diagnostic, formative, summative, self and peer assessment practices are essential part of climate education. These practices support and supplement each other. Furthermore, the teacher's role as a part of assessment practices is analysed and examples of the assessment practices are introduced and discussed.

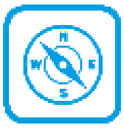
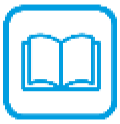
3.3 Module's structure and orientation for learning outcomes' structure

One of the most important aspects in education, and in teacher training in particular, is the definition of the "role" that the learner – the trainee – is implicitly or explicitly asked to play. Trainee teachers are indeed both professionals, with their experience, knowledge and beliefs, and learners, within a formation path.

The definition of trainees' role and the relationship between trainers and trainees are crucial for the success of a training activity. In order to make it explicit, CLIMADEMY assumes a model developed by Barquero & Bosch (Barquero & Bosch, 2015, p. 261), within the paradigm established by the anthropological theory of the didactic (ATD) for mathematics education (Chevallard, 1992). This model is known as "Study and Research Paths for Teacher Education (SRPs-TE) (Barquero, Bosch & Romo, 2018). This model has been already modified and used in the Erasmus + project IDENTITIES. CLIMADEMY, for its activities, refers to the version developed for IDENTITIES and here further elaborated.

The adaptation of the structure of the particular SRPs-TE consists of four types of activities (see table 1 and Fig.7). Each of them asks teachers (participants) to assume different roles.

Table 1 – Trainee teacher's possible roles (the icons are taken from the IDENTITIES project)

Type 1: **Trainee teacher as an *explorer***	 	In **Type 1** participants are asked to address initial questions, to share their knowledge and play the role of "*explorers*". This type of activity aims to break and ice and to have a first look to what exists, what emerges from and around them. In this type of activities all the participants are invited to share their knowledge, experiences, beliefs.
Type 2: **Trainee teacher as a *student***		In **Type 2** participants are asked to play the role of "*student*" or "*apprentice*". The main goal of this type of activity is to make participants get familiar with new contents or activities that could, to a certain extent, be also reproduced and used in an ordinary secondary classroom. This type of activity is supposed to convey novel knowledge or methods to the teachers.
Type 3: **Trainee teacher as an *analyst***		**Type 3** invites the participants to assume an external, "meta", position from which to analyse the materials and the activities they have experienced in the previous type. They are invited to change the role and adopt the role of "*analyst*". At this stage, educators introduce some tools/instruments to progress collectively with participants on the analysis of the materials.
Type 4: **Trainee teacher as a *designer***		**Type 4** consists of sharing some secondary school experiences with participants. Through the presentation of real case studies in secondary school, participants are expected to elaborate on how to use the tools to re-design and adapt the activity for their classes. They are invited to adopt the role of "*designer*".

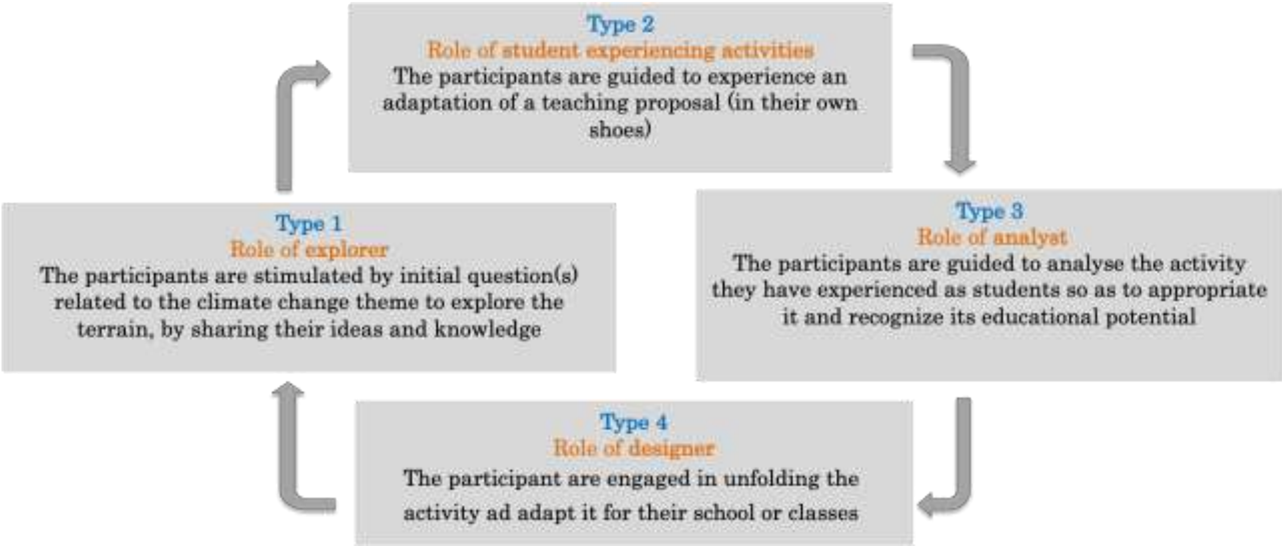


Fig. 7 Adaptation in submodules' structure of the SRP-TE
(adaptation from Barquero et al., 2018)

In the SRPs-TE model, the different types are supposed to constitute submodules to be carried out in sequence. In CLIMADEMY, this is recommended, but the model is mainly used to make the role of the trainees explicit and guide the co-designers to construct the activities taking into account the multiple roles that teachers can and should play throughout their training (students, analysts, designers and implementers).

3.4. Pedagogical principles and methods

The fourth component of our model concerns, explicitly, pedagogical principles.

We use the term "pedagogical principles" to name recommendations for the implementation of the activities in real classes of teacher education. The principles are important to maintain or exploit the innovation potential of the materials and foster deep and active engagement of the students. They can be also used in classes of secondary school students and, in this sense, they can be also explicit object of formation in the contexts of teacher education.

While planning and organizing events, supportive for teachers' professional learning, it is important to take into account what is known about teachers' professional learning. The outcomes of research on teachers' professional development and learning emphasizes the long-term nature of the professional learning (Oliveira, 2010), teachers' active role in their professional learning (Garet et al., 2001), connection of learning to the classrooms and practice context, and collaboration and reflection with colleagues (Avalos, 2011; Kitchen & Figg, 2011; Luft & Hewson, 2014; Van den Bergh et al., 2015), because traditional in-service training has been recognised to be ineffective (Opfer & Pedder, 2011). One serious reason for this ineffectiveness is that teachers' professional learning activities fail to consider how learning is embedded in professional lives and working conditions, i.e., teacher community and classrooms (Koffeman & Snoek, 2019). Teachers are considered to be active in professional learning when they control or regulate their own learning by setting aims for learning and reflecting on and self-assessing their own learning processes and products. Collaboration during reflection helps in the sharing of beliefs and/or experiences and enables learning from experiences (Hiebert et al., 2002). However, while planning the activities it is important to remember that teachers' professional learning and how this learning is supported through various activities depends also on education context, traditions and policy.

In the following we introduce the concept of *participant framework* to illustrate the sense of pedagogical principles and to suggest an activity to discuss on them with the trainees.

Then, we present the MERID framework as the one we suggest for implementing the activities in the teacher training activities.

A way to break the ice and open the discussion on the pedagogical principles in context of teacher education is to introduce the concept of *participant framework.* This concept can help to provide criteria to characterize the dynamics of teaching/learning within their class. For this reason, we present them as prompts that can be used with the teachers to guide them to reflect on their own practices.

Participant frameworks*:* structures that outline class scenarios where interactions take place by describing the rights, roles, and responsibilities of participants in a setting with respect to the issue of “Who can speak what and when?” (Hegedus & Penuel, 2008).

Examples of participant frameworks that can be discussed with the teachers are the following ones, taken from Tabak and Baumgartner (2004) and freely elaborated:

- **“teacher as monitor”:** this participant structure is characterized by an asymmetrical relationship between the teacher and the learners, where the nature of instruction is the following: the teacher is the repository of the knowledge, s/he initiates the discourse, asks about procedures, tasks and completion of task-related milestones. At the end, it is up to the teacher to evaluate and close the conversational routine.

- **“teacher as mentor”:** this participant structure is still characterized by an asymmetrical relationship and the nature of instruction is also explicit, but unlike in the monitor framework, this participant framework leaves “room for interpretation, negotiation, and adaptation of ideas, rather than the testing and evaluation” (Tabak & Baumgartner, 2004, p. 403). In this participant structure, knowledge can be also generated by the students and “the teacher tries to help the students to align their thinking and actions with scientific norms without dictating actions or explanations” (Tabak & Baumgartner, 2004, p. 403).

- **“teacher as expert-partner”:** here the teacher assumes a different posture, “the teacher presents herself as a peer” and “joins the group for a few minutes and takes part in their investigation as a genuine member of the group” (Tabak & Baumgartner, 2004, p. 403). In “teacher as partner” the teacher is no longer the sole authority and multiple students are authorized to speak; knowledge is distributed and can be generated by the single participants and/or by the classroom interaction.

- **“teacher as partner”:** here “the teacher presents herself as a peer” and “joins the group for a few minutes and takes part in their investigation as a genuine member of the group” (Tabak & Baumgartner, 2004, p. 403). In “teacher as partner” the teacher is no longer the sole authority and multiple students are authorized to speak; knowledge is distributed and can be generated by the single participants and/or by the classroom interaction.

- **“teacher as moderator of the discussion”:** here the teacher chairs a discussion and does not take sides saying who is right. Knowledge is not on the teacher, and it is assumed to be distributed and generated by the single participants and/or by the classroom interaction.

- **“teacher as perspective-maker”:** this structure can emerge in co-teaching contexts, where each teacher plays the role of an expert of one possible view. Knowledge is distributed among the teachers and the students, and it can be generated by the single participants and/or by the classroom interaction.

In the previous description, the criteria used to characterize a participant framework are:

- Knowledge generation: Where does knowledge come from? Who is supposed to be "source of knowledge"?

- Knowledge distribution flow and accountability: How is the knowledge distributed in the class? Who has the accountability to speak ("who can speak what and when?")

- Teacher role and discourse pattern: what is the role of the teachers? Is she/he supposed to lead a "directive discourse pattern oriented to test and evaluate", or to lead an "indirective pattern aimed to facilitate the ideas exploration or a collective discussion"?

To activate a discussion in context of teacher training, we suggest using the following schematic pictures (Fig. 8 a, b, c, d) as representation of classroom dynamics and ask the teachers to describe them in terms of the previous criteria. Cases a), b) represent the most familiar way to imagine a classroom dynamics. Case c) is supposed to represent a case of co-teaching and, already this one, can create some discomfort, touching some elements of teacher professional identity: "being THE source of the entire knowledge". In the digital era and in the society of uncertainty where complex and inner interdisciplinary themes like climate change have to be addressed in school, a more realistic picture of what classroom dynamics should be imagined is represented in Fig.8(d). The discussion on this image can be very fruitful to invite the teachers to imagine or re-imagine of their role and their position with respect to knowledge, students, colleagues and society more in general.

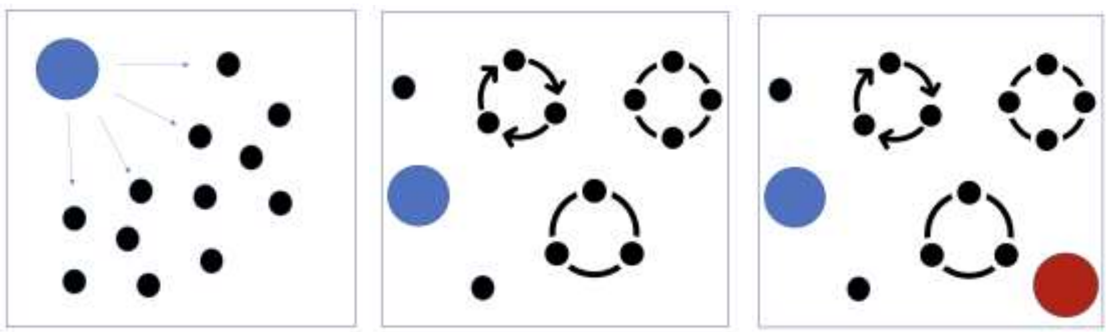


Fig. 8 (a, b, c) - Classroom dynamics representations. Fig. 8.a) suggests a typical lecture dynamics, where the teacher (blue dot) exposes knowledge (arrows) to the students (black dots); Fig. 8.b) suggests a teamwork, facilitated by the teacher (blue dot); Fig. 8.c) suggests a case of co-teaching during teamwork.

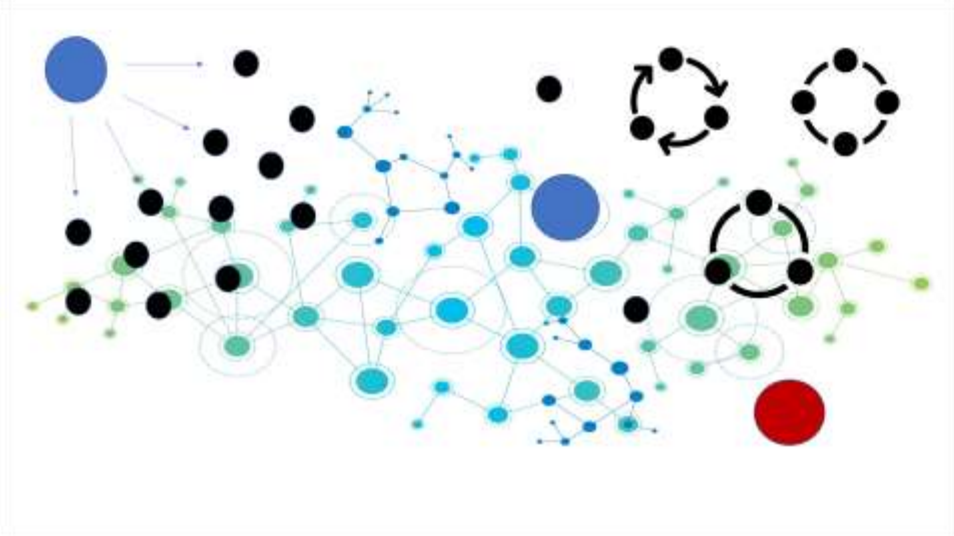


Fig. 8(d) – Classroom dynamics representation in the digital era, when knowledge generation and sharing cannot avoid the presence of the web.

As for the role of teacher trainers, in CLIMADEMY we suggest to implement the pedagogical principles embedded in what is called "educative mentoring".

Educative mentoring is a collaborative and reciprocal relationship within which both the mentor and mentee engage in inquiry into practice aiming at both parties' professional growth (Bradbury, 2010). In this regard, educative mentoring can be considered as a more mediating practice that promotes the active construction of knowledge within real educational contexts. The goal of educational mentoring remains to meet the immediate needs of the mentee-teachers, but also to promote a long-term professional development of mentees through their initiation to an exploratory attitude towards their daily practice (Bradbury, 2010). As such, educative mentoring presents many points of convergence with the definition of learning communities by Stoll et al. (2006) as "a group of people sharing and critically interrogating their practice in an ongoing, reflective, collaborative, inclusive, learning-oriented, growth-promoting way operating as a collective enterprise". Therefore, by the conjunction of mentoring and communities of learners, mentees have the opportunity to benefit from the shared knowledge and the social interaction with both the more experienced mentor and peers as well.

The practices and the roles mentors assume during these conversations are of great importance as they influence the level of mentees' active engagement in analysing and reflecting on their practical experience. Hennissen et al. (2008) in an extensive literature review described a wide variety of mentors' practices that ranged from directive (such as assessing, advising, confirming and providing feedback) to non-directive (such as asking questions, developing alternatives, summarizing).

MERID is a two-dimensional model which incorporates two aspects of mentoring dialogues: the mentor's style (degree of directiveness) and his/her initiative of introducing topics for conversation (degree of input). According to the MERID model, the aforementioned dimensions, the degree of mentor's directiveness and the degree of initiation of topics for discussion define four distinct mentoring roles in the context of mentoring conversations, as shown in Fig. 9:

- the imperator, who introduces topics for discussion and uses directive skills to support his/her mentees,

- the initiator, who introduces topics for discussion but uses questions and other non-directive mentoring skills to address these topics,
- the advisor, who uses directive skills like instructions and advice to address the topics introduced by the mentee, and
- the encourager, who uses non-directive skills to elicit mentees' opinions on the topics that the mentees themselves had originally introduced.

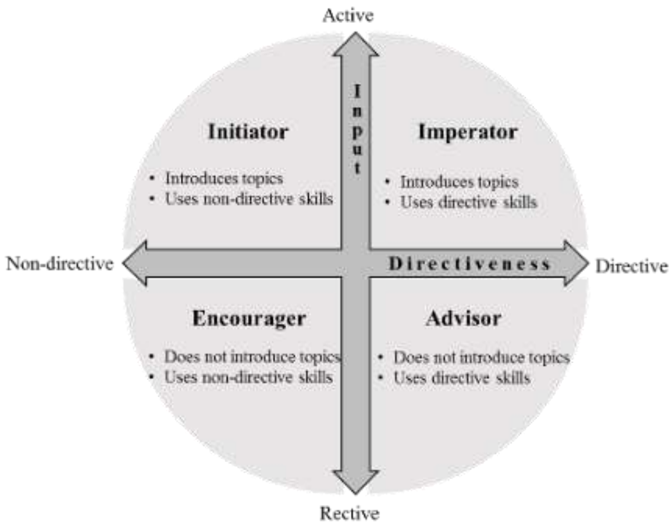


Fig. 9 The MERID model (Michailidi & Stavrou, 2021)

Mentors participate in the mentoring conversations with different roles, shifting their mentoring style in the course of mentoring meetings and among the discussed topics. Specifically, as mentees gain experience, mentors shift their mentoring style towards non-directive skills (e.g. from lesson modelers to encouragers). In fact one of the most significant and influential factors that determine the success of mentoring is the extent to which mentors' approach matches and is able to address mentees' learning needs (Michailidi & Stavrou, 2021).

3.5. Assessment guidelines

Rationale behind Assessment

When assessment is discussed in educational contexts, including teacher training, it is always very important to highlight that the concept of assessment refers to the actions which are supportive to the learning process and the actions which are aimed at determining the amount and quality of the learning outcome (Black & Wiliam, 2009). Thus, assessment is a much wider concept than "grading": assessment also includes actions that provide feedback for the students and information for the teacher about the students' learning process, without the need to assign grades to the students. In this context, assessment is related to the aims of the climate education lesson or a larger climate education module or even on climate education competence framework. In this framework, as already stressed, values and attitudes are seen as the foundation of climate change competence of the youth. Scientific knowledge and ability to search new information on climate change is the basic competence in the framework. Creativity and ability to design new solutions is needed to build sustainable futures. Action competence brings competence to real life.

When an assessment action makes a judgement or grade of the performance of a student, the type of assessment is summative (Wiliam, 2000). While supporting the learning process, the type of assessment is formative. These two main types of assessment require individual or collective interpretation of the aims for teaching and learning.

In an assessment action, the focus is always on both the quality of the learning process (the formative type of assessment) and the learning outcome (the summative type of assessment) with a focus on improving students' learning process and outcomes. Therefore, both the teacher and the students use assessment data for developing teaching and learning. This type of assessment is called enhancement-led assessment (Patton, 2011; Atjonen, 2015). Consequently, it is important to support students in using assessment feedback in the development of their learning process and learning outcome. Therefore, simple testing has limitations in supporting the learning of climate competences in a versatile way (OECD, 2020).

The assessment actions are always based on the verified evidence and the grading is done according to the criteria or a rubric. A rubric is a tool, which helps in assessing students' learning outcomes or an artefact created during the learning process. A rubric usually includes three essential features: evaluative criteria, quality definitions of the criteria at particular levels, and a scoring strategy (Dawson, 2007).

Assessment in the context of climate education could be challenging for many reasons. First, the aims for climate education are set holistically or the climate competence framework is complex. For example, a teacher could support students to acquire at the same time several competences, such as, climate values, core knowledge in the domain and skills needed in generating alternatives. Consequently, a teacher should assess the achievement of several aims at the same time. Second, the assessment of the learning process could be challenging because of the several activities students are guided to engage in. For example, a teacher can guide students to collaborate and engage in scientific and engineering knowledge practices and, moreover, ask them to construct an educational artefact, such as a poster or a report. Knowledge practices refers to practices that are similar to climate researchers or designers, such as asking questions, defining problems, planning, and carrying out investigations, analysing and interpreting data, developing, and using models, generating alternatives or solutions and communicating information (Krajcik & Czerniak, 2013). Third, the created artefacts could also be assessed, not only the learning outcomes and process. To be considered as an artefact, it needs to be lasting, durable, public and materially present (Frederik, 2011). Moreover, aesthetic aims, such as exceptionality and diversity, ethical aims and aims related to sustainability, are often emphasized as aims for the artefact.

In the previous paragraph, it was mentioned that the aims for climate education are often set holistically. This means that in addition to climate education aims, also aims for learning transversal competencies (also called key competencies, generic competencies, or 21st century competencies) are set for a lesson or study module. For example, creative and critical thinking skills, collaboration and problem-solving skills, skills needed in the use of various tools, such as digital and manual tools are considered as transversal competencies (Voogt & Roblin, 2012). Therefore, aims related to the transversal competencies form a group of aims which could be assessed as a part of climate learning (Pepper, 2011). However, the aims related to the transversal competencies are often not shared with the students (Scott & Yates, 2002). Therefore, self-assessment and peer-assessment that move learners forward do not necessarily focus enough on the learning of transversal competencies.

The assessment and the feedback affect how the students learn, collaborate, and change their behavior (Weeden et al. 2002). Assessment with encouragement supports the student's self-concept as a responsible citizen. This type of encouragement and constructive feedback is supportive in the development of students' self-efficacy, in other words their belief in their capacity to execute behaviors necessary to the use their knowledge and creativity (Bandura, 1997). Self-efficacy reflects confidence in the ability to exert control over one's own motivation, behavior, and social environment. Climate change mitigation on an individual level does not depend only on opportunities for action but also on one's self-awareness and self-efficacy (Bianchi et al., 2022). Mitigation has a strong attitudinal aspect – the willingness to act.

Encouragement and constructive feedback could improve students' growth or mindset (Nadelson, 2021). Therefore, the assessment actions should indeed be constructive and encouraging during the lesson or larger climate module. However, the students need to understand the feedback and according to that, direct their learning and behavior in the desired direction. The feedback is directed and connected to each student's actions and outputs. The students are directed simultaneously to interpret feedback so that it will be easier for them to change their own way of behavior.

Quality Assessment

The quality of assessment depends on the characteristics of assessment, such as validity, reliability, objectivity and authenticity. According to the validity characteristics, the assessment should focus on the attitudes, values, knowledge and skills or competencies that are aimed at climate education. In the context of this document, the assessment should focus on essential and relevant issues, described in the climate competence framework. Thus, the starting point for the assessment should be the competence framework. Moreover, the assessment should be open and transparent, and the participants must know the competence framework, including aims for learning transversal competencies, and the assessment practices planned to be used. Therefore, it is important to pay attention to the aims of the lesson or the teaching module and the expected learning outcomes: students and teachers should share the same aims. After sharing the aims, assessment practices to be used should be agreed. In practice, the students should be invited to be involved in the planning of the lesson or module and planning its assessment (McAlpine, 2002; McMillan, 2013).

The demand for the reliability of the assessment includes the fact that the assessment tools could be interpreted in a similar way and assessment practices do not contain random errors and that every student is given feedback and support according to their needs and process and product are assessed according to the agreed criteria in the same way. The objectivity of the assessment includes the fact that the effect of the subjective factors, values and preconceptions have been removed (McAlpine, 2002; McMillan, 2013).

The authenticity of assessment refers to the practices used in assessment. The practices should be in line with the pedagogical approaches and learning environments used. Authenticity refers also to the next-stage studies and competences needed in adult life.

Assessment Types and Methods

Diagnostic, formative and summative types of assessment are main types of assessment (see Fig.10). The aim of diagnostic assessment is to determine what the student already knows before teaching. Diagnostic test, asking questions and observations are tools for diagnostic assessment. Formative assessment provides feedback on learning-in-process and steer the process towards goals. Formative test, questioning and observing, self-assessment forms are used for tools in formative assessment. Summative assessment is used at the end of the learning process for evaluating students' learning against the competence framework. Therefore, it sums up and predicts the performance in future studies after the learning process. Well planned summative exams or tests or use of concept maps could be used for summative assessment (McAlpine, 2002; McMillan, 2013).

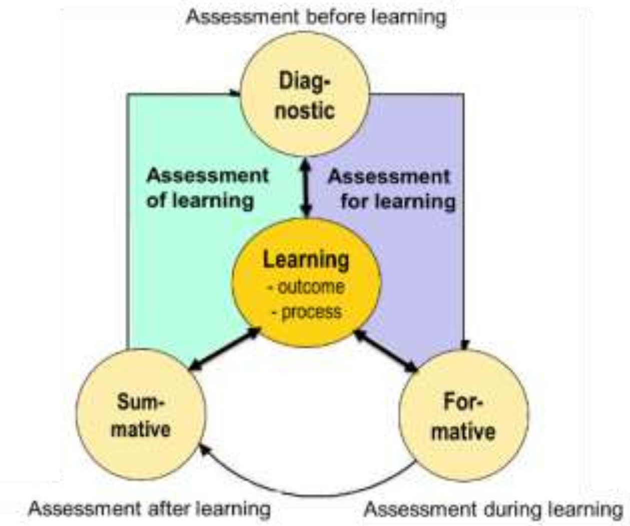


Fig. 10 Main types of assessment

Assessment could be formal or informal. Formal assessment is the systematic where tests or other tools that measure what and how well the students have learned are used. Formal assessments determine the students' proficiency or mastery of the content and can be used for comparisons against competence framework or curriculum aims. Examples of formal assessment are standardized tests or systematic use of student assignments. Informal assessments are spontaneous and could be easily incorporated in day-to-day classroom activities. Informal assessments are content and performance driven. Examples of informal assessment are checklist, observation, and questioning. (McAlpine, 2002; McMillan, 2013),

	Formative Assessment	Summative Assessment
Informal	Questioning Feedback Peer assessment Self-assessment	Essays in uncontrolled conditions Portfolios Coursework Teacher assessment
Formal	Further analysis or tests, exams, essays Target setting	Tests Exams Essays in controlled conditions

Fig.11. Purposes and tools for assessment

Finally, we can mention that there are several other views to assessment. For example, assessment could be teacher or student directed. If assessment is student-directed activity it is called as student self-assessment. (McAlpine, 2002; McMillan, 2013).
In Annex A, a more detailed description of exemplar tools for diagnostic, formative assessment is reported. It can be used with the teachers to spark their imagination and make aware instruction design.

The key massage that we suggest is that both formative and summative assessment are needed, and they can be realized also through self- and peer assessment practices in climate education. Both types of assessment are carried out according to the holistic aims, objectives or learning outcomes descriptions. Formative assessment supports students learning during the process. Summative assessment summarizes the student's learning outcomes. Therefore, it is more than grading and a single grade might not be enough for summarizing. In this document alternative assessment tools, such as self-assessment, use of portfolio and assessment of artefacts. The use of the portfolio method or construction and assessing of artefacts enables both the short- and long-term tracking of learning activities and thus gather the evidence for assessing the process and finally assess summatively the reached level.

4. CLIMADEMY Template for Instruction activities and prototypes of activities

In section 4.1, we report the schematic structure of a possible CLIMADEMY activity for teacher training that implements the pedagogical model drafted so far.

In section 4.2, two examples of activity description are illustrated in detail.

4.1. CLIMADEMY template

<table>
<tr><td>Activity or module: (TITLE)</td></tr>
<tr><td>Description of the activity, in terms of:
Title
Duration
Target groups
Related disciplines:
Physics
Chemistry
Biology
Geology
Mathematics
Engineering
Others: ________________________________
Brief description of the activity</td></tr>
<tr><td>Articulation of the activity in sub-activities (in case), by referring to the role of the trainee teachers

</td></tr>
<tr><td>For each sub-activity, briefly describe:
a) educational reconstruction components in terms of:</td></tr>
</table>

Core scientific concepts (the result of elementarization) of the activities (what the trainee teachers and then the secondary school students should know)

Educational enrichment and relevance of the contents

Research references on students' conceptions.

b) Links to the Competence Frameworks
c) Participant structures
d) Learning outcomes and assessment tools

The template was built to provide the guidelines with practical orientation for making the model alive and usable in the practice (Rossi, 2023).

The final structure is here:

[ACTIVITY TEMPLATE - empty.pdf]()

The template is supposed to guide the design and implementation of the teacher training activities as follows:

- Use the STE-PE model to reflect on the role you wish the teachers should play and structure, accordingly, the analysis, discussion or presentation of activities for teacher education;
- For each phase of the STE-PE model, design specific tasks to achieve explicit learning outcomes for your teacher education actions on CC in which mentors and mentees have a specific role;
- In each activity and training phase, consider the MER, ERTE and CoRE to point out the key pedagogical messages that are worth discussing and use guiding questions to orient the discussion with the teachers;
- Use the template to guide the analysis, discussion or presentation of the activity for teacher education by answering the selected questions.

In the following section, we illustrated the template by using an existing and already well-established activity designed for a teaching/learning module on climate change (Tasquier, 2015; Tasquier et al., 2016; 2017; Barelli, 2017; Levrini et al., 2019; 2021; I SEE project[1]; IDENTITIES project[2]), named the "biodiesel activity".

4.2. Prototypes of activities

In this section we present a prototypical activity, by focusing on: the main goal of these phases, the link with the frameworks of the pedagogical model and the suitable guiding questions.

The description is the result of a re-analysis of a well-established activity, carried out following the principles of the CLIMADEMY pedagogical model. This process of re-working on a well-consolidated activity helps methodologically to focus on how to use the model. As a result of this first process, the first draft of the template emerged. This draft was discussed with the small and the big group of

[1] Erasmus+ Programme (Grant Agreement n°2016-1- IT02-KA201- 024373) https://iseeproject.eu/
[2] Erasmus+ Programme (Grant Agreement n°2019-1- IT02-KA203- 063184) https://identitiesproject.eu/

researchers both at local and global level of the CLIMADEMY project and was refined through several steps. Once arrived at a stable version, the template was also proved against a new situation, by using it to design a new activity from scratch, the “Atlas activity”, inspired by an exemplary activity presented by the Finnish group of teachers.

Briefly, in the explorer phase, the mentee explores the topic/phenomenon proposed by the mentor, focusing on which knowledge should be part of instruction and which not. In this phase, since the target is an activity for students, the mentee teacher should identify which knowledge should be used and which not. The identified guiding questions are the following:

- What should students learn about the topic/text?
- What else should teachers know about this topic – not going to teach to students (the level of scientific content)?

In the student phase, mentee teachers are invited to study the key concepts of the topic/phenomenon, the contexts in which this topic/phenomenon is or can be embedded, the epistemic competences that students could develop through the educational material used to carry out the activity on the topic/phenomenon, and the students’ difficulties. These are key elements of the educational reconstruction process. Precisely, the key concepts are the result of the ‘elementarization’ process. Identifying the contexts and the epistemic competences, and considering the students' difficulties with the topic/phenomenon are key ingredients of the enrichment process. The identified guiding questions are the following:

- What are the core ideas/big ideas/key concepts and models of the topic?
- What are the epistemic competences this activity can develop?
- In which contexts are the activity’s key concepts/scientific content embedded?
- What are the students’ difficulties with the topic/activity?

In the analyst phase, the mentee has to analyse the topic/phenomenon and the related activity for students more deeply, focusing on its educational value. Therefore, besides the relevance and meaning that the activity under investigation can have for students, the CLIMADEMY competences that could be developed through the activity (targeted for students) are supposed to be identified in this phase. The identified guiding questions are the following:

- Why is it important (meaningful and relevant) for students to learn this topic?
- What competences does the analysed activity aim to develop?
- How are these competences developed?
- How can they be assessed?

Finally, in the designer phase, the mentee teachers can focus on implementing the activity under investigation in their classroom, adapting it or designing a different one if necessary. They are invited to think about the role of the teacher in the classroom and the source of knowledge. The participant framework and the MERID model play a relevant role in this phase. The identified guiding questions are the following:

- Which is the source of knowledge?
- Which participant structure will you use to enact this activity?
- Which degree of directiveness and input will be used in the classroom?

Here, you can download the description as an example for mentor teachers to show how the pedagogical model can be used in practice for teacher education.
ACTIVITY TEMPLATE - Biodisel 1.pdf
ACTIVITY TEMPLATE - Biodisel 2.pdf

5. Conclusions

The deliverable D3.1 reflects the work conducted in the frame of WP3, tasks 3.1 and 3.2. The draft model has been built through a collaborative process among the partners and the other WPs. In particular, new educational material (WP2) has been revised or developed according to the educational model from WP3 and transformed into prototypes of teaching activities for teacher education. These activities are implemented in the CLIMADEMY network established in WP4 and the implementations are providing new insights to revise and improve the WP3 model, whose delivery is foreseen for the end of the project (M36).

References

Developing the pedagogical model

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. Teaching and Teacher Education, 27(1), 10–20. https://doi.org/10.1016/j.tate.2010.08.007

Barquero, B., Bosch, M., & Romo, A. (2018). Mathematical modelling in teacher education: Dealing with institutional constraints. ZDM, 50(1-2), 31–43. https://doi.org/10.1007/s11858-017-0907-z

Barquero, B., & Bosch, M. (2015). Didactic engineering as a research methodology: From fundamental situations to study and research paths. Task Design In Mathematics Education, 249–272. https://doi.org/10.1007/978-3-319-09629-2_8

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (formerly: Journal of Personnel Evaluation in Education)*, *21*(1), 5-31.

Bianchi, G., Pisiotis, U., Cabrera Giraldez, M. (2022). *GreenComp – The European sustainability competence framework*. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/13286, JRC128040.

Bosch, M. (2018). Study and Research Paths: a model for inquiry. International Congress of Mathematicians, World Scientific Publishing Co. Pte. Ltd., Rio de Janeiro, 4001-4022.

Bradbury, L. (2010). Educative mentoring: Promoting reform-based science teaching through mentoring relationships. Science Education, 94(6), 1049-1071.

Chevallard, Y. (1992). Fundamental concepts in didactics: Perspectives provided by ananthropological approach. In: Douady R, Mercier A (eds) Research in Didactique of Mathematics. Selected Papers. La Pensée sauvage, Grenoble, France, pp 131-167.

Chevallard, Y. (2002). Organiser l'étude. 3. Écologie & régulation. Actes de la XIe école d'été de didactique des mathématiques (pp. 41-56). Grenoble: La Pensée Sauvage.

Chevallard, Y. (2015). Teaching mathematics in tomorrow's society: A case for an oncoming counter paradigm. In S.J. Cho (Ed.), Proceedings of the 12th international congress on mathematical education (pp. 173–187). Berlin: Springer.

Dawson, P. (2017) Assessment rubrics: towards clearer and more replicable design, research and practice. *Assessment & Evaluation in Higher Education, 42*(3), 347-360.

Duit, R., Gropengießer, H., Kattmann, U., Komorek, M., & Parchmann, I. (2012). The Model of Educational Reconstruction – A framework for improving teaching and learning science. In D. Jorde

& J. Dillon (Eds.), The World of Science Education: Science Education Research and Practice in Europe (pp.13-37). Rotterdam: Sense Publishers.

Favier, T., Van Gorp, B., Cyvin, J.B., & Cyvin, J. (2021) Learning to teach climate change: students in teacher training and their progression in pedagogical content knowledge, Journal of Geography in Higher Education, 45:4, 594-620. https://doi.org/10.1080/03098265.2021.1900080

Frederik, I., Sonneveld, W. & de Vries, M.J. (2011). Teaching and learning the nature of technical artifacts. *International Journal of Technology and Design Education, 21*, 277–290. https://doi.org/10.1007/s10798-010-9119-3

Garet. M., Porter. A., Desimone, L., Birman, B. &Yoon, K.S. (2001). What makes professional development effective? Results from a national sample of teachers. American Education Research Journal, 38(4), 915–945. https://10.3102/00028312038004915

Hennissen, P., Crasborn, F., Brouwer, N., Korthagen, F., & Bergen, T. (2008). Mapping mentor teachers' roles in mentoring dialogues. Educational research review, 3(2), 168-186.

Hestness, E., McGinnis, J.R. & Breslyn, W. (2015). Integrating Sustainability into Science Teacher Education Through a Focus on Climate Change. In S.K. Stratton et al. (eds.), Educating Science Teachers for Sustainability, ASTE Series in Science Education (pp. 143-162). Springer. https://doi.org/10.1007/978-3-319-16411-3_9

Hiebert, J., Gallimore, R., & Stigler, J. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? Educational Researcher, 31(5), 3–15. https://doi.org/10.3102/0013189X031005003

Jorgenson, S.N., Stephens, J.C., & White, B. (2019) Environmental education in transition: A critical review of recent research on climate change and energy education, The Journal of Environmental Education, 50(3), 160-171. https://doi.org/10.1080/00958964.2019.1604478

Kitchen, J., & Figg, C. (2011). Establishing and sustaining teacher educator professional development in a self-study community of practice: Pre-tenure teacher educators developing professionally. Teaching and Teacher Education, 27(5), 880–890. https://doi.org/10.1016/j.tate.2011.02.003

Koffeman, A. & Snoek, M. (2019) Identifying context factors as a source for teacher professional learning, Professional Development in Education, 45(3), 456-471, https://10.1080/19415257.2018.1557239

Krajcik, J. S., & Czerniak, C. M. (2013). *Teaching science in elementary and middle school: A project-based approach*. Taylor and Francis.

Loughran, J., Mulhall, P., & Berry, A. (2008). Exploring Pedagogical Content Knowledge in Science Teacher Education. International Journal of Science Education, 30(10), 1301–1320. https://doi.org/10.1080/09500690802187009

Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. In S. K. Abell & N. Lederman (Eds.), Handbook of research in science education (2nd ed., pp. 889-909). Taylor and Francis.

McAlpine, M. (2002). *Principles of Assessment.* https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=ea2226f3f264a33f260adf7a516ccc81f09c5ca9

McMillan, J.H. (ed.) (2013). *Handbook of Research on Classroom Assessment*. SAGE

Michailidi, E., & Stavrou, D. (2021). Mentoring in-service teachers on implementing innovative teaching modules. Teaching and Teacher Education, 105, 103414.

Nadelson L. S. (2021) Makerspaces for rethinking teaching and learning in K–12 education:

Introduction to research on makerspaces in K–12 education special issue. *The Journal of Educational Research, 114*(2), 105-107. https://doi.org/10.1080/00220671.2021.1872473

OECD (2020). *Education policy outlook: Finland. OECD Education Policy Outlook series*. OECD. https://www.oecd.org/education/policy-outlook/country-profile-Finland-2020.pdf

Oliveira, A. W. (2010). Improving teacher questioning in science inquiry discussions through professional development. Journal of Research in Science Teaching, 47(4), 422–453. https://doi.org/10.1002/tea.20345

Opfer, V. D., & Pedder, D. (2011). Conceptualizing Teacher Professional Learning. Review of Educational Research, 81(3), 376–407. https://doi.org/10.3102/0034654311413609

Pepper, D. (2011). Assessing Key Competences across the Curriculum — and Europe. *European Journal of Education, 46*, 335-353. https://doi.org/10.1111/j.1465-3435.2011.01484.x

Scott, G., & Yates, K. W. 2002. Using successful graduates to improve the quality of undergraduate engineering programmes. *European Journal of Engineering Education, 27*(4), 363-378.

Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional learning communities: A review of the literature. Journal of Educational Change, 7(4), 221–258.

Stratton S.K., Hagevik R., Feldman A., Bloom M. (2015) Toward a Sustainable Future: The Practice of Science Teacher Education for Sustainability. In: Stratton S., Hagevik R., Feldman A., Bloom M. (eds) Educating Science Teachers for Sustainability. ASTE Series in Science Education. Springer, Cham. https://doi.org/10.1007/978-3-319-16411-3_23

Van den Bergh, L., Ros, A., & Beijaard. D. (2015). Teacher learning in the context of a continuing professional development programme: A case study. Teaching and Teacher Education, 47(1), 142–150. https://doi.org/10.1016/j.tate.2015.01.002

van Ginkel, G., Oolbekkink, H., Meijer, P. C., & Verloop, N. (2016). Adapting mentoring to individual differences in novice teacher learning: The mentor's viewpoint. Teachers and Teaching: Theory and Practice, 22(2), 198-218.

Voogt, J., & Roblin, N.P. (2012). A comparative analysis of international frameworks for 21st century competencies: Implications for national curriculum policies. *Journal of Curriculum Studies, 44*(3), 299-321. https://doi.org 10.1080/00220272.2012.668938

Wiliam, D. (2000). The meanings and consequences of educational assessments. *Critical Quarterly, 42*(1), 105-127.

Weeden, P., Winter, J. & Broadfoot, P. 2002. *Assessment. What's in it for schools?* London: Routledge Falmer.

References on Assessment

Anderson, L. W. and Krathwohl, D. R., et al (Eds.) (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Allyn & Bacon.

Andrade H. L. (2019). A Critical Review of Research on Student Self-Assessment. *Frontiers in Education, 4*, https://doi.org/10.3389/feduc.2019.00087.

Atjonen, P. (2015). "Your career will be over"—Power and contradictions in the work of educational evaluators. *Studies in Educational Evaluation*, *45*, 37-45.

Brady, L. (2011). Assessing Values Education: A Tentative Exploration. *Curriculum Perspectives, 31*(3), 49–55.

Bell, B. & Cowie, B. (2001), The characteristics of formative assessment in science education. *Science*

Education, 85(5), 536-553. https://doi.org/10.1002/sce.1022

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (formerly: Journal of Personnel Evaluation in Education), 21*(1), 5-31.

Bianchi, G., Pisiotis, U., Cabrera Giraldez, M. (2022). *GreenComp – The European sustainability competence framework*. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/13286, JRC128040.

Brown, T., Rongerude, J., Leonard, B., & Merrick, L. C. (2021). Best Practices for Online Team-Based Learning: Strengthening Teams through Formative Peer Evaluation. *New Directions for Teaching and Learning, 2021*, 53– 64. https://doi.org/10.1002/tl.20436

Curren, R., & Kotzee, B. (2014). Can virtue be measured? *Theory and Research in Education, 12*(3), 266–282. https://doi.org/10.1177/1477878514545205

Dawson, P. (2017) Assessment rubrics: towards clearer and more replicable design, research and practice. *Assessment & Evaluation in Higher Education, 42*(3), 347-360.

Doran, R. L., & Tamir, P. (2002). *Science educator's guide to laboratory assessment*. NSTA press.

Flowers, A., Carroll, J., Green, G., & Larson, L. (2015). Using art to assess environmental education outcomes. *Environmental Education Research, 21*(6), 846–864. https://doi.org/10.1080/13504622.2014.959473

Frederik, I., Sonneveld, W. & de Vries, M.J. (2011). Teaching and learning the nature of technical artifacts. *International Journal of Technology and Design Education, 21*, 277–290. https://doi.org/10.1007/s10798-010-9119-3

Granit-Dgani, D., Kaplan, A., & Flum, H. (2017). Theory-based assessment in environmental education: a tool for formative evaluation. *Environmental Education Research, 23*(2), 269–299. https://doi.org/10.1080/13504622.2016.1144172

Grob, R. , Holmeier, M. , & Labudde, P. (2017). Formative Assessment to Support Students' Competences in Inquiry-Based Science Education. *Interdisciplinary Journal of Problem-Based Learning, 11*(2). https://doi.org/10.7771/1541-5015.1673

Harris, C. J., Krajcik, J. S., Pellegrino, J. W., & DeBarger, A. H. (2019). Designing Knowledge-In-Use Assessments to Promote Deeper Learning. *Educational Measurement: Issues and Practice, 38*(2), 53–67. https://doi.org/10.1111/emip.12253

Hattie, J. (2009). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. New York, NY: Routledge.

Jahnukainen, M. 2011. Different strategies, different outcomes? The history and trends of the inclusive and special education in Alberta (Canada) and in Finland. Scandinavian Journal of Educational Research, 55(5), 489–502.

Johnson, B., & Manoli, C. C. (2011). The 2-MEV Scale in the United States: A Measure of Children's Environmental Attitudes Based on the Theory of Ecological Attitude. *The Journal of Environmental Education, 42*(2), 84–97. https://doi.org/10.1080/00958964.2010.503716

Juuti, K., Lavonen, J. & Salmela-Aro, K. (Eds.) (2022). *Projektioppiminen luonnontieteissä [Project-Based learning in Sceince Education]*. Gaudeamus. https://doi.org/10.31885/9789523458437

Karpudewan, M., Roth, W.M. & Bin Abdullah, M. N. S. (2015) Enhancing Primary School Students' Knowledge about Global Warming and Environmental Attitude Using Climate Change Activities.

International Journal of Science Education, 37(1), 31-54, https://doi.org/10.1080/09500693.2014.958600

Kimball, M. (2005). Database e-portfolio systems: A critical appraisal. *Computers and Composition*, *22*(4), 434-458.

Kimbell, R. 2012. The origins and underpinning principles of e-scape. International Journal of Technology and Design Education, 22(2), 123-134.

Kollmuss, A. & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3). 239-260, https://doi.org/ 10.1080/13504620220145401

Kloser, M., Borko, H., Martinez, J.F., Stecher, B., & Luskin, R. (2017), Evidence of Middle School Science Assessment Practice From Classroom-Based Portfolios. *Science Education, 101*(2), 209-231. https://doi.org/10.1002/sce.21256

Krajcik, J. S., & Czerniak, C. M. (2013). *Teaching science in elementary and middle school: A project-based approach*. Taylor and Francis.

Leighton, J. P., & Gierl, M. J. (eds.) (2007). *Cognitive diagnostic assessment for education: Theory and applications*. (New York, NY, US: Cambridge University Press).

Manoli, C., Johnson, B.,& Dunlap, R. (2007). Assessing Children's Environmental Worldviews: Modifying and Validating the New Ecological Paradigm Scale for Use With Children. *The Journal of Environmental Education, 38*, 3-13. 10.3200/JOEE.38.4.3-13. https://www.researchgate.net/publication/254345096_Assessing_Children's_Environmental_Worldviews_Modifying_and_Validating_the_New_Ecological_Paradigm_Scale_for_Use_With_Children

Marshall, J. A. , & Harron, J. R. (2018). Making Learners: A Framework for Evaluating Making in STEM Education. Interdisciplinary Journal of Problem-Based Learning, 12(2). Available at: https://doi.org/10.7771/1541-5015.1749]

McAlpine, M. (2002). *Principles of Assessment*. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=ea2226f3f264a33f260adf7a516ccc81f09c5ca9

McMillan, J.H. (ed.) (2013). *Handbook of Research on Classroom Assessment*. SAGE

Merttens, R. (1996). Assessing Children's Personal Development: The Ethical Implications. In J.M. Halstead & M.J.Taylor (Eds.), *Values in Education and Education in Values* (pp. 191-202). London: Falmer.

Mislevy, R., & Haertel, G. (2006). Implications of evidence-centered design for educational testing. *Educational Measurement: Issues and Practice*, 25(4), 6– 20. https://doi.org/10.1111/j.1745-3992.2006.00075.x

Nadelson L. S. (2021) Makerspaces for rethinking teaching and learning in K–12 education: Introduction to research on makerspaces in K–12 education special issue. *The Journal of Educational Research 114*(2), 105-107. https://doi.org/10.1080/00220671.2021.1872473

OECD (2007). *PISA 2006: Science competencies for tomorrow's world, volume 1: Analysis*. Paris: OECD.

OECD (2013). *PISA 2012. Results in focus. What 15-year-olds know and what they can do with what they know.* Paris: OECD Publishing. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

OECD (2020). Education policy outlook: Finland. OECD Education Policy Outlook series. OECD. https://www.oecd.org/education/policy-outlook/country-profile-Finland-2020.pdf

Patton, M. (2011). Developmental evaluation. New York, NY: Guilford press.

Parker, M., Ndoye, A., & Ritzhapt, A. (2012). Qualitative analysis of student perceptions of e-portfolios in a teacher education program. Journal of Digital Learning in Teacher Education, 28(3), 99-107

Pepper, D. (2011). Assessing Key Competences across the Curriculum — and Europe. *European Journal of Education, 46*, 335-353. https://doi.org/10.1111/j.1465-3435.2011.01484.x

Roczen, N., Kaiser, F. G., Bogner, F. X., & Wilson, M. (2014). A Competence Model for Environmental Education. *Environment and Behavior, 46*(8), 972-992. https://doi.org/10.1177/0013916513492416

Rosenheck, L., Lin, G.C., Nigam, R., Nori, P. and Kim, Y.J. (2021), "Not all evidence is created equal: assessment artifacts in maker education", *Information and Learning Sciences*, *122* (3/4), 171-198. https://doi.org/10.1108/ILS-08-2020-0205

Scott, G., & Yates, K. W. 2002. Using successful graduates to improve the quality of undergraduate engineering programmes. *European Journal of Engineering Education, 27*(4), 363-378.

Shepardson, D. P. Niyogi, D., Choi R. & Charusombat, U. (2009) Seventh grade students' conceptions of global warming and climate change. *Environmental Education Research, 15*(5), 549-570. https://doi.org 10.1080/13504620903114592

Voogt, J., & Roblin, N.P. (2012). A comparative analysis of international frameworks for 21st century competencies: Implications for national curriculum policies. *Journal of Curriculum Studies, 44*(3), 299-321. https://doi.org 10.1080/00220272.2012.668938

Webb, M. & Jones, J. 2009. Exploring tensions in developing assessment for learning. Assessment in Education: Principles, Policy & Practice, 16(2), 165–184.

Wiliam, D. (2000). The meanings and consequences of educational assessments. *Critical Quarterly*, *42*(1), 105-127.

Weeden, P., Winter, J. & Broadfoot, P. 2002. Assessment. What's in it for schools? London: Routledge Falmer.

Zubizarreta, J. 2009. The learning portfolio: Reflective practice for improving student learning. John Wiley & Sons.

Annex A - Assessment tools: further guidelines and examples

Diagnostic Assessment: Assessment before learning
The aim of diagnostic, declarative or planning assessment is to find the values, skills and perceptions and knowledge needed by the students in climate education. Tools for diagnostic assessment include various tests, teacher questioning and observations (Leighton & Gierl, 2007). The questions posed by the teacher directs the student to look at certain characteristics of climate education. The student's response tells the teacher what the student thinks about the topic. For example, a review related to the mitigation of climate change can begin with the question: "How can you save energy?" and "How can you save materials?"
A diagnostic test, Kahoot (https://kahoot.com/) or Socrative (https://www.socrative.com/) activity could also be used to map the students' conceptions or skills: Which of the following activities consume energy most in European Union a) education, b) transport, c) food and beverages. The teacher asks questions they know as being critical to the success of the work: "How are the results reported?", "What keywords did you think you should use in a search?" In a similar way, it is possible to map the way in which the students have understood the aims of the learning activity: "What and how we are evaluating in this activity?" The questions help students to think about the aims of the learning process.

Karpudewan et al. (2015) used following questions for mapping students' pre-conceptions in their study on child-centered, 5E[3] learning cycle-based climate change activities:

- What is global warming?
- What do you understand about global warming?
- What is the cause for global warming?
- If we had a way of making sure that there was no rubbish in rivers, is that going to help reduce global warming?
- Explain how we combat global warming by making sure the rivers are clean?
- Do you turn off the air conditioning or other electrical appliances when not in use? How often do you perform this behaviour?

In the context of diagnostic assessment, students often respond in an unexpected way because the topic has not yet been learned and they do not know the concepts or skills needed in the learning activity. Therefore, it is particularly important to provide encouraging feedback to students. After the student's answer, a teacher naturally continues with a follow-up question. If the answer is vague, the student may be given an opportunity to modify the answer. The teacher can repeat or slightly modify the student's answer, for example, by asking, "Do you mean that…" (repeating the answer in your own words), "You bring up perspectives A and B, would there be other perspectives?", "What do you think about C?" The types of feedback given by a teacher can be grouped as follows:

- Encouraging feedback: emphasizing competence
- Evaluative feedback: highlight positive perspectives and ask to look at it from another perspective, for example
- Guiding feedback: how the objectives should be considered in the future

Formative Assessment: Assessment during learning
Formative assessment is used for supporting the students' learning process. Moreover, peers could be active in giving feedback during the process, such as during the communication sessions, which are

[3] The "5E" refers to the five phases of the Learning Cycle, namely Engage, Explore, Explain, Elaborate, and Evaluate.

typically used within inquiry or project type of learning. For example, students could be asked to communicate the phase of their learning to other students and the teacher after the students have formulated the question, problem or challenge according to which they will learn. Typical type of formative assessment are:

- Observations during in-class activities; of students non-verbal feedback during lecture
- Homework exercises as review for exams and class discussions
- Reflections in portfolio or in other type of document that are reviewed periodically during the semester
- Question and answer sessions, both formal—planned and informal—spontaneous
- Conferences or discussions between the instructor and student (and parent) at various points in the semester
- In-class activities where students informally present their results
- Student feedback collected by periodically answering specific question about the instruction and their self-evaluation of performance and progress (Bell & Cowie, 2001)

The feedback provided by the teacher, as well as the self-assessments and peer assessments help the students to understand their learning and to identify the development of their values, attitudes, knowledge or skills and areas where competencies are not yet sufficient. The students learn to correct their mistakes and develop their working so that the goals set for their learning can be achieved. The feedback could be given orally, adding comments to the portfolio or learning diary or with structured forms. Therefore, it is important that at different stages of their learning, students communicate to the teacher and to each other about the stage of the learning process and outcomes.

Formative assessment guides regulate the student's working and learning toward the aims set for learning. Its primary function is to help students to discover what they know and how, or are able to do, and what still needs to be learned and in what way (Webb & Jones 2009). Formative assessment helps the teacher to focus his or her support and supervision on issues that students do not yet know. Formative assessment can also support the student's feeling of competence. The need for competence is one of the key basic psychological needs or motivating factors in learning.

Summative Assessment: Assessment after learning

An essential characteristic of summative assessment is making the achievement of the aims, objectives or learning outcomes and, moreover, the learning process visible. In a summative assessment attitudes, values, knowledge and skills, which have been developed or learned could be assessed. Summative assessment is based on verified evidence of how well and to what extent the student has achieved the aims set for the lesson or climate education module (Doran & Tamir, 2002). Various assessment tools, such as examinations or tests, an examination where materials or internet could be used, a screening test, and systematic use of e-portfolio could be used in summative assessment. Moreover, it is possible to assess concrete outcomes of the learning process, artefacts, such as essays, concept maps, project reports and presentations or a learning diary.

There are several points of views that should be considered while planning an examination or a test for measuring the learning outcomes. First, summative assessment as any other assessment is done according to the aims, objectives or learning outcomes descriptions of the climate education module. For the purposes of summative assessment, it is common to prepare a framework, which is used in the development of the assessment and the content to be assessed. The framework helps the design of assessment tools, such as test and test items. For example PISA Scientific Literacy Framework, introduced in the Programme for International Student Assessment (PISA) (Organisation for Economic Co-operation and Development in 2007, but revised in 2013. [OECD], 2013), have been used for the design of PISA Science test and test items. This framework initially defines three competencies, which describe the use of science subject knowledge and knowledge about science and, moreover, willingness (attitude) to use this knowledge in three situations (skills): in identifying scientific issues, in explaining scientific phenomena and in drawing evidence-based conclusions. This framework also concentrates on various situations or contexts where attitude, knowledge and skills are developed. The initial PISA framework further introduced personal, local and global situations and contexts in three main areas: science in life and health, science in the Earth and its environment, and science in technology.

Harris et al. (2019) have suggested a design process for constructing knowledge-in-use assessment tools and items. This approach provides meaningful and actionable information about students' progress toward knowledge-in-use learning goals. The design process has origins in the evidence-centered design (ECD) (Mislevy & Haertel, 2006), which has gained attention as a comprehensive approach for principled assessment design and validation. ECD provides a framework for analysing content for assessment design that can be used to specify the essential and assessable components of knowledge-in-use learning goals. We slightly modified the original test and item design model for climate knowledge-in-use (Fig.13). This model involves two phases: domain analysis, which involves unpacking of the climate competences in the performance expectations to understand the assessable components; and domain modeling, which involves item and test design including the design of item type, cognitive process and knowledge type and, moreover, the use of additional material, such as, additional text or data material. Fig.14 presents an integrated climate competence dimension map, which is recommended to construct after first unpacking disciplinary core knowledge or practices, scientific and engineering practices and values and attitudes in the context of climate competences. This climate competence dimension map has the same components as it is described in the PISA framework.

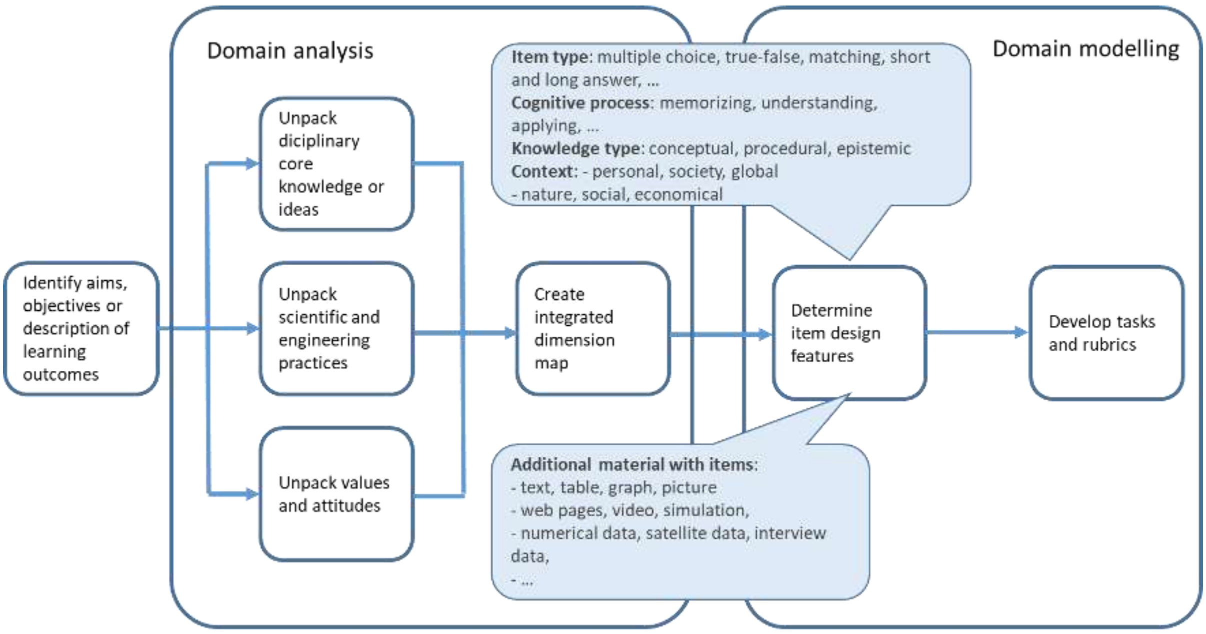


Fig.13. Design process for constructing knowledge-in-use assessment items.

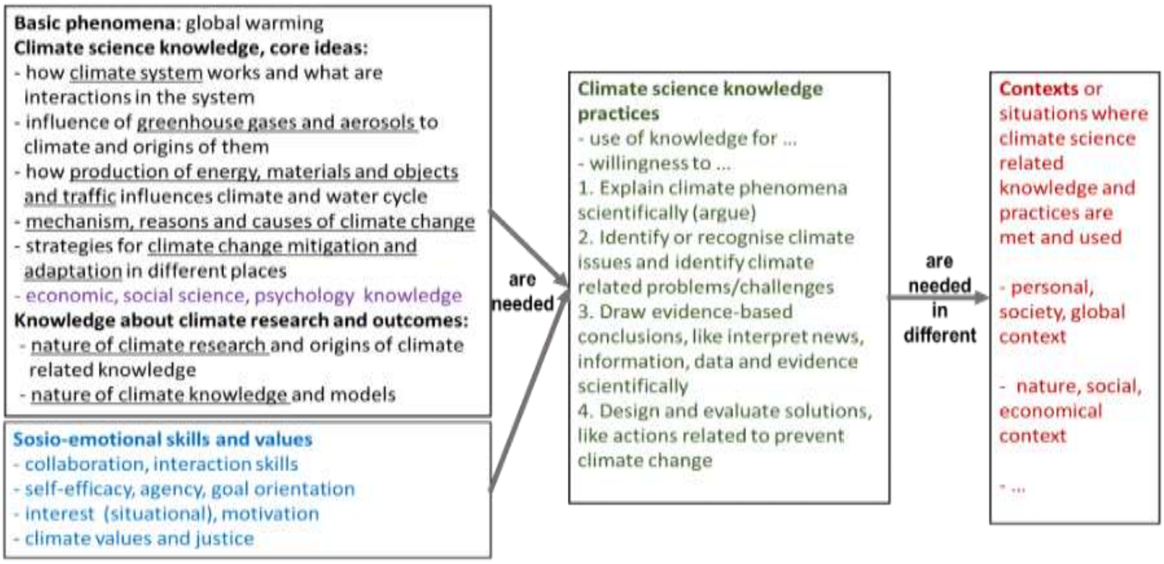


Fig. 14. Integrated climate competence dimension map

Examinations and tests are structured in several ways and several item types are used in the test, such as, objective items (true-false, multiple choice, matching, put in order, …), short answer questions (question, fill-in, crossword, …), essay, and problem-solving question. True or false type items are simple statements, which must be either completely true or completely false. The statement should not be very long and it is not appropriate to use statements with words like always, never, no, sometimes and often. Moreover, negative statements could be avoided.

Short answer questions could be asked using different forms, such as question, fill-in and crossword. Different type of short answer questions:
1. Definition question: require to define a concept (What is an acid?)
2. Explanation question: require to explain why something is true or how something functions (What happens in neutralisation?)
3. Example question: require a specific real-world example of a concept or phenomenon (Give example of acids)
4. Relationship questions: require to state or show how two or more things relate to one another (Are they the same? Are they different? Are they opposites?)
5. Calculation question: require to calculate or compute a numerical answer or response.
6. Graphing question: require an answer in the form of a graph (Draw a graph, which describes neutralization).

Essay test items demand long answers and it enquires the students to use knowledge rather than memorize information. Much time is required to answer this type of question as the student has to plan, organize and reflect. Student has to express his/her ideas in writing clearly and concisely hence only a few questions can be asked within the limited time in as much as the test cannot cover the whole curriculum. Example of an essay test item: Why is the average temperature of the Earth increasing?

New knowledge is learned at different levels. Firstly, it is possible to repeat what has been learned, ie. to recall the knowledge, and secondly, new knowledge could be used in a familiar context. The third level is the application of learned knowledge to new situations involving problem-solving (Fisher 1990: 1 - 28). Consequently, cognitive processes are wary between the levels and are less demanding in lower levels. Anderson and Krathwohl (2001) developed a taxonomy, which is a revision of Bloom's taxonomy, which categorizes cognitive processes in 6 levels as described in Table 2. Table also introduces test items, which aims to measure use of knowledge in a certain level of cognitive process.

Table 2. Examples of test items measuring student understanding of recycling in different levels

Cognitive process	**Verbs**	**A test item about recycling**
Remember (recognise or recall knowledge, facts or concepts)	define, describe, identify, label, list, name	What is recycling?
Understand (construction meaning from instructional message)	illustrate, compare, explain, classify, interpret, summarize	Why is recycling important?
Apply (use ideas and concepts in a new situation or in problem solving)	implement, organize, construct, demonstrate, modify, prepare, relate, solve	Give examples of recycling at home and at supermarkets. How can you develop recycling habits in your home?
Analyse (breaking something down into components, significance of components),	analyse, break down, compare, select, contrast	What happens if we stop recycling? What happens to materials and energy in recycling?
Evaluate (making of judgement or assessment on the basis of criteria or standards)	rank, assess, monitor, judge	Evaluate possibilities and constrains for recycling in your home city?
Create (recognise diverse elements to form a new pattern or structure)	generate, plan, develop, create, invent, construct, produce, design	Design a recycling plan for your school.

Anderson and Krathwohl taxonomy also has a knowledge dimension and introduces four types of knowledge: (1) factual knowledge; (2) conceptual knowledge; (3) procedural knowledge and (4) meta-cognitive knowledge. Epistemic knowledge is added to the original dimension.

Table 3. Knowledge dimension in Anderson and Krathwohl taxonomy.

Knowledge type	**Definition**	**Example question**
Factual knowledge	information on terminology and details	Name two greenhouse gases.
Conceptual knowledge	knowledge of different classes and categories, generalizations, theories, models and structures.	What is the reason for global warming
Procedural knowledge	knowing how to do something, algorithms, techniques, methods, and criteria for the use of knowledge.	A class decided to start measuring outdoor temperature in order to know how it is changing during one year. Present a plan for the study.

Epistemic knowledge	which knowledge is correct by one reasoning, but may be false based on another, knowledge of how new knowledge is created, justified, and used.	How do we know that the average temperature of Earth is slowly increasing?
Metacognitive knowledge	knowledge of strategies, knowledge of the cognitive requirements of the task, and knowledge of one's own strengths and weaknesses.	Evaluate your actions from the point of view of global warming

The cognitive test Shepardson (2009) used for measuring seventh grade students' conceptions of global warming and climate change is a good example of a test, which measures use of conceptual and procedural knowledge in various situations. Moreover, the items measure at least an understanding level of cognitive process.

Summative assessment can also be done by an observation form, a learning diary, a portfolio, or based on a screening test. Documents, reports, blogs, or videos produced by the students could also be assessed. Summative assessment could be implemented through the assessment of the artefact created during the learning process. A specific assessment sheet, constructed based on the aims of the learning, could be used in the assessment of the artefact.

For assessing students' answers to examination or test items, a rubric is needed. A rubric is a type of scoring guide that articulates specific components and expectations for an assignment. Rubrics can be used also for a variety of assignments, such as documents, reports, blogs, videos, portfolios, and presentations.

	Culture: Our school develops a culture of sustainability with the wider community			
	Starting	**Challenging**	**Committing**	**Transforming**
Rubric **Vision and values**	The need to examine our school's sustainability vision and values is identified	Our school undertakes an inclusive community process to develop its sustainability vision and values	There is evidence of commitment to the vision and values through all areas of school life	Core vision and values are practised, renewed and shared across communities to build more sustainable lifestyles
Core indicator	School community (students, staff and parents) has: • engaged in reviewing our current vision and values e.g. caring and respect to include EfS.	School community (students, staff and parents) has: • developed our vision and values with current and potential partners to include EfS.	Students, staff, parents and community members have: • demonstrated and communicated our sustainability vision and values in everyday practices i.e. 'walking the talk'.	Communities are: • renewing and sharing visions, values and sustainable lifestyles.
Rubric **Interconnectedness**	Our school considers how to integrate the social, environmental and economic factors of sustainability	Some of our practices reflect a balance between social, environmental and economic factors	Our school places equal value on social, economic and environmental factors when making decisions	Through a culture of sustainability, social, environmental and economic factors are integrated
Core indicator	School community (students, staff and parents) has: • considered the scope of sustainability and how it fits with educational purpose.	School community (students, staff and parents) has: • implemented strategies to integrate sustainability factors into our decision and policy making processes (e.g. item on meeting agendas.	Students, staff, parents and community members have: • reviewed our policy documents e.g. purchasing to ensure that decisions are made considering all sustainability factors.	Communities are: • making sustainability a priority in all decision making.
Rubric **Whole-school approach**	Individuals consider and identify their role in education for sustainability	Groups consider ways to coordinate and integrate their work with the school's sustainability vision	There is whole-school commitment to achieving the sustainability vision	Our school is part of a sustainable community
Core indicator	School community (students, staff and parents) has: • invited a range of people to examine how they can contribute to EfS.	School community (students, staff and parents) has: • started discussing and documenting how the EfS vision guides our sustainability actions.	Students, staff, parents and community members have: • demonstrated that our actions within and beyond the school consistently reflect our vision and values of sustainability.	Communities are: • working together to generate innovative practices and achieve sustainability goals.

Note: EfS = Education for Sustainability

Fig. 16. An example of a rubric for Education for Sustainability, published by the Government of Australia (https://cdn.environment.sa.gov.au/landscape/docs/hf/nr_amlr_aussi-sa_education_for_sustainability_rubrics_and_core_indicators.pdf)

Student self-assessment

Through self-assessment, the students find out what they have learned, compare their learning to the set aims, and strive to find out what should still be learned. They can also recall how they have engaged in the learning process and how they could engage more effectively next time. Self-assessment is thus like formative assessment and intended to support the learning process and learning outcome. It helps students to become responsible for their learning. Self-assessment also supports the development of metacognitive skills, self-confidence, and self-image. In addition to learning, the use of a self-assessment method develops readiness for further studies and adult life (Andrade, 2019).

It is known that self-assessment is challenging for students. Therefore, students' self-assessment should be supported by teacher led discussion, teacher questioning, or assigning a task. The discussion can be started by asking the student to share their experiences of their learning process in general. Next, the student could be asked to look at their own activity during the learning and to think about what kind of problems they had. Finally, the students could be encouraged to analyse how they can develop their learning. The self-assessment could be started with a question, "What was the most interesting / surprising / charming thing today?". Other examples of questions that guide the self-assessment process include: "List the three most important things you learnt today" and "What else would you have liked to learn?" Students can be asked to write the answers on a common page on a digital platform. After writing, they can be instructed to compare their responses and discuss each other's experiences. It is important to guide students to evaluate their learning in a small group, for example: "How have you succeeded in your group in collaboration, idea generation and communication?" "How can you improve your learning in a group?"

The form in Fig. 17 could be used for guiding the self-assessment. There may be fixed and open-ended questions on the form (see Table 3).

What can I do? (1 = I need exercise, 2 = moderately, 3 = well)
1. I am able to search for information. 1 2 3
2. I am able to generate ideas. 1 2 3
3. I am able to evaluate ideas. 1 2 3
4. I am able to write notes. 1 2 3
5. I am able to work in a group. 1 2 3
6. I am able to communicate. 1 2 3
7. I am able to assess my learning. 1 2 3
8. I am able to assess artefacts created during the learning process. 1 2 3
What was most interesting related to learning today?
What else would you like to learn today?

Fig.17. Example of self-assessment form of students' activities.

Peer-assessment

The group can also self-evaluate their own activities using other forms or relying on a discussion. As the group evaluates their own activities, group members become aware of how each group member and the group as a whole has worked. In peer review, a student evaluates the work of another student or a group. In this case, it is important to encourage students to be positive in the assessment and to bring up a number of perspectives. Any criticism presented should be done so constructively (Brown et al., 2021).

The Digital Portfolio - a method for Knowledge Building, Interaction, and Assessment

The digital portfolio, a briefcase or a folder refers to the collection of the displays of student assignments, descriptions of the learning process and outcomes. The display discloses the student's diverse abilities and the reached competence levels depending on the portfolio assignment type: the open assignment type reveals more detailed and unexpected information than the ready-to fill-in type (Parker et al., 2012; Kimball, 2005). The content of the portfolio, collected documents, consist of the process descriptions, the choices available, and the self-assessments/the group assessments and describe success and recognized challenges and objectives for further learning.

Alongside the authentic documentation, the portfolio consists of two more basic elements: reflection and collaboration (Zubizarreta, 2009). The portfolio develops in the portfolio process from a container to a reflective report and even to a dialog (Kimbell, 2012). The content of the portfolio diversified as the inexperienced student became accustomed to the method and the simplest documenting is transformed into a more diverse holistic or even abstract narration (See also Saarinen et al., 2021). The collected materials can be processed, reflected, immediately and/or later at an appropriate time.

Portfolio can contain a range of types of assessment: it can be shared online with the teacher when the process feedback is direct and formative by nature. If the portfolio is shared with the peers, the peer-feedback can be directed towards content or criteria and due to its formative nature, it also supports the process. Finally, the contents of the portfolio comprise the material for summative assessment purposes.

One principle of the portfolio assessment is that the working and the progress of it, the best achievements, and failures and coping with them are stored. One's own development is examined and with the help of the documentation, reflected either to construct a statement or the deepest level of reflective thinking (Kimball, 2005). Then also the mistakes and failures are seen but not emphasized in the same way as for example in the traditional assessment, which is based on the use of summative tests. On the other hand, the examination of mistakes and their corrections show versatile skills and abilities, and therefore it is desirable for the portfolio documentation to contain errors and mistakes. The portfolio assessment is an attempt to strengthen learning to learn and the self-direction as well to develop self-esteem.

When compiling the portfolio student:

- analyse, selects and sets own objectives for himself
- designs and selects studying tasks suitable to the objectives and approaches
- shows and uses information independently and adapts it
- examines and estimates own learning process and the learning results, in other words own work and working
- discerns personal strengths, subject interests and learning challenges
- considers the grounds for the successful learning and the significance of collaboration and role of own working.

It is recommended to start by a review of the portfolio, going through the principles of how the portfolio works, sectors (elements) and their role in the assessment (the criteria for assessment).
The typical stages of the portfolio work carried out at schools are as follows:

1. Common and own aims or objectives for learning subject matter, knowledge and skill are set together and their assessment criteria are agreed on.
2. The learning process is designed together based on the objectives and it is carried out.
3. During and at the end of the study module the students will estimate progress independently in group and/or with teacher and they reflect the samples contained in the portfolio.
4. The student can, if so desired, distribute the samples chosen by him/her and his/her own estimate of their level and of own development to other students, teachers and possibly also older and friends so that they can become acquainted with the working of the study module and with the encouraging assessment debate.
5. In the assessment both the results and the process descriptions, progress and enterprise are taken

into consideration.

Assessing artefacts
An "artefact" refers to tangible objects or outcomes of the learning process, created by the students. These can include textual artifacts such essays, concept maps, project reports, presentations, and learning diaries, but also concrete objects such as artwork, technological objects, crafts etc., or audiovisual artefacts such as videos (Kloser et al., 2017; Rosenheck et al., 2021). Role of artefacts in learning are especially emphasized in inquiry or project-based learning. In this type of learning, students create a set of tangible artefacts, like graphs and tables with digital tools that address the driving question. These are shared artefacts, that is, publicly accessible external representations (Krajcik & Czerniak, 2013).

The produced artefacts can be used for summative assessment of the students' learning outcomes (Rosenheck et al., 2021). Artefacts could be used also in formative, self- and peer-assessment. However, Grob et al. (2017) raise various challenges in formative assessment. Firstly, it takes time, especially, the preparation of written assessment, if they are done several times. Secondly, self- and peer-assessment also need a certain amount of practice to be effective: The students need some exercise in assessing and providing feedback before peer-assessment can really improve learning and the artefacts.

In the context of climate education, the number of points of views in the assessment of artefacts could be high. First, the starting point in assessment is in the climate competence model: Values and attitudes, scientific knowledge and ability to search new information on climate, creativity and ability to design new solutions, and action competence. Second, the artefact as such could be assessed from the ethics and aesthetic point of views and how well it communicates the "message".

The assessment of student-produced artefacts, like all assessments, must always be based on the given assignment and the learning goals that have been set for that assignment. The two example rubrics provided below illustrate this. The first rubric is intended for evaluating a learning project in physics, where the students must produce a model that describes the movement of objects based on experimental evidence. The second rubric is meant for assessing student products created in "maker education", and the assessment criteria reflect the learning goals of maker education. In holistic climate change education, the assessment criteria should reflect the key climate change competencies. Artefacts can also be assessed from aesthetic and ethical perspectives, whenever relevant to the learning goals: in climate change competencies, this could mean assessing the artefacts from the perspective of the competence area "Embodying sustainability values".

Table 4. A rubric used for assessing an artefact (a model) in project-based learning (Juuti et al., 2022).

	5 Excellent	4	3 Good	2	1 Poor
Does the model answer the guiding question?					
Concepts and their use					
The produced model					
Argumentation					
Clarity and appearance					

Assessing values and attitudes

There is little research on values and attitudes in the context of climate education and what is published is typically written based on environmental attitudes and values in general.

The assessment of students' values and attitudes is concerned with formative and diagnostic assessment. The summative assessment of student values has been found to be counterproductive or even harmful and ethically questionable (Curren & Kotzee, 2014; Merttens, 1996) and high-stakes testing in ethics education has been found to be similarly counterproductive for achieving holistic ethics education (Sporre, 2019). Furthermore, depending on the local curriculum, it may be explicitly forbidden to use students' values and attitudes as basis of summative assessment or grading. Thus, assessment of values refers here to the assessment of students' environmental values for the purpose of supporting their learning process and, moreover, their future actions related to climate and environmental issues.

Values and attitudes form the foundation of climate change competences. Thus, to create optimal learning moments, it is crucial that teachers are aware of their students' values and attitudes. It is also important for students to self-assess their values to become aware of them. Several value assessment instruments have been developed that could be used, possibly in an adapted form, for student self-assessment. These include the New Environmental Paradigm Scale (NEP) and the New Environmental Paradigm Scale for Children (Anderson, 2012; Manoli, Johnson & Dunlap, 2007). The 2-MEV scale (Johnson & Manoli, 2011), intended to be used with 10 to 12-year-olds, measures the preservation and utilization dimensions of ecological values: preservation values have been found to correlate with pro-environmental behavior (Pauw & Petegem, 2013). A third scale measures the egotistic, biospheric and altruistic value orientations: the biospheric value orientation correlates with pro-environmental behavior (de Groot & Steig, 2008). Ranking tasks, in which students rank values or value statements in order of personal importance, can also be used in student self-assessment. For example, Brady (2011) suggests that students can rank following value-statements for self-assess their values (2-MEV scale):

- *I try to tell others that nature is important.*
- *To save energy in the winter, I make sure the heat in my room is not too high.*
- *I like the quiet of nature.*
- *Weeds should be killed because they take up space from plants we need.*
- *People are supposed to rule over the rest of nature.*

Teacher observations on students' behaviour, actions and talk offer information about the students' values and attitudes: Values as such are difficult to observe. This can occur during class activities in which students engage with environmental values, such as debates, dialogues, small group discussions and role-playing (Shephard, 2008). In this way, the learning and assessment of values occur simultaneously, and the teacher can use the results of this formative assessment to further support the learning of environmental values.

Flowers, Carroll, Green and Larson (2015) explored methods of using drawing assessments to assess the environmental attitudes and awareness of primary school aged children. However, they note that art methods may give different results from more traditional measurement scales depending on the learner, and thus different assessment methods should be combined to get a fuller picture of the students' values and attitudes.

Environmental values and attitudes do not exist separately from environmental knowledge. Kollmuss and Agyemann (2002) see environmental values, attitudes, knowledge and emotional involvement as forming a complex they call "pro-environmental consciousness", and Roczen et al. (2014) found that attitudes and knowledge affect each other. Thus, students' values and attitudes cannot be assessed as if they formed an area separated from their knowledge; rather, the students' knowledge should be considered when assessing their values and attitudes.