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CLIMADEMY Final Conference and Teachers' Climate Change Forum 2025

31 March – 3 April 2025
Hyytiälä Forest Station, Juupajoki, Finland

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WELCOME TO THE CLIMADEMY CONFERENCE AND TCCF 2025

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Keywords: Climate Change Education, Teacher Education, Lifelong Learning.

INTRODUCTION

It is our distinct pleasure to welcome you to participate in and read the proceedings of the final conference of CLIMADEMY (CLIMAte change teachers' acaDEMY) project combined with TCCF (Teachers' Climate Change Forum), held at Hyytiälä Forest Station in Finland during 31 March – 3 April, 2025.

As the global community faces the profound challenges posed by climate change, it has become increasingly clear that education holds the key to fostering a generation of informed, empowered, and solution-oriented citizens. As the architects of young minds, teachers are uniquely positioned to inspire meaningful action and cultivate critical thinking on sustainability and resilience. This conference aims to equip educators with the tools, knowledge, and strategies needed to effectively teach climate change across diverse contexts and curricula.

The CLIMADEMY Conference and TCCF 2025 bring together education professionals and researchers who are passionate about climate science and sustainability in education. The four-day event will feature workshops, interactive sessions, keynote talks, and research presentations focused on the collaborative development of key competencies to effectively teach climate change in schools and communities.

CLIMADEMY (climademy.eu) is a three-year Erasmus+ project that aims to create a European partnership of teacher's education and training providers across Europe. It develops the European and international dimensions of teacher's education and contributes to the achievement of the objectives of the European Education Area. Specifically, CLIMADEMY has offered a comprehensive program for teachers, leading to a better understanding of climate change and an effective methodology for teaching the next generation of European citizens. According to our vision, the result of the project will contribute to prepare the new generations to face the challenges of the next decades in terms of sustainable development, mitigating and adapting to climate change, protecting the environment and fighting inequalities.

CLIMADEMY has created a new European network of teacher education and training providers. The consortium (from 4 EU countries, Greece, Germany, Italy and Finland) has developed and established a strong European network and community of practice on teacher education. It has developed an online CLAUDI platform (claudi.chemistry.uoc.gr) for sharing of climate change educational material. It has brought together universities with cutting-edge research on climate change, high-quality initial teacher education and continuing professional development. It has also involved other nationally recognized providers of teacher education and continuous professional development, not forgetting the schools, which enable the practical training essential to teacher education.

TCCF is an activity organized in collaboration between LUMA Science Helsinki and Institute for Atmospheric and Earth System Research INAR. TCCF focuses on climate science, climate education and

the connection between the two. It develops different models for collaboration between scientists and teachers through collaborative design-based research (Aksela and Tolppanen, 2022). The forum has been organized annually since 2017. In 2019, it was hosted for the first time in Hyytiälä Forest Station, and due to the pandemic, it was held online in 2020-2022 online and as a blended event with local participants in Hyytiälä Forest Station and remote attenders online. Recently, the international network Regional Centres of Expertise on ESD (RCE) awarded a prestigious commendation in the Climate Action category to TCCF.

We wish the participants of the CLIMADEMY/TCCF conference rewarding and enjoyable three days. Together, we will explore a wide range of topics, including innovative teaching methodologies, interdisciplinary approaches, and the integration of novel scientific research into classroom practice. Our program features inspiring keynote speeches, oral and poster presentations, and engaging and interactive workshops, and opportunities to network with professionals from around the world. Each session is designed to inspire collaboration and provide actionable insights that you can take back to your institutions and communities. Let us use this opportunity not only to learn from each other, but also to build lasting partnerships that will advance climate literacy and empower the next generation to face the challenges of our changing world.

ACKNOWLEDGEMENTS

The work done within CLIMADEMY has been supported by the Erasmus+ Programme (Call: ERASMUS-EDU-2021-PEX-TEACH-ACA, Project ID 101056066).

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You can find presentations and auxiliary material of the abstracts in this book in the CLAUDI platform (https://claudi.chemistry.uoc.gr/).

Contents

Abstracts

HOW TO START AND BUILD A COMMUNITY WITH TEACHERS ON CLIMADEMY VALUES: THE ITALIAN HUB EXEMPLE

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Keywords: Community building, Climademy Competence Framework, Values and Attitudes, Action

INTRODUCTION

One of the key aspects of the Erasmus+ Teachers Academy call is to facilitate networking, knowledge sharing, capacity building, mobility and providing teachers and trainers with learning opportunities at all phases of their careers. This is to improve the attractiveness of the teaching profession, and to promote professional development opportunities. The Climademy European Project took up this challenge also intending to promote teachers' communities of practice at a local and transnational level. Teachers are considered co-designers who actively collaborate with the project partners producing training contents.

This workshop aims to share and to discuss some tools and insights about community building and community making carried out by Fondazione Golinelli. Over the past two years, the Fondazione Golinelli team facilitated a group of 32 Italian teachers participating in the hub as co-designer teachers and schools. The facilitation objective has been to help teachers to consolidate their skills, supporting horizontal collaboration and exchange, starting from field experiences with colleagues and students.

How do you build a community of teachers and researchers who work together, experiment, compare and truly exchange resources as equals to grow individually and collectively, especially on climate change priorities, including the commitment to sustainability and climate action opening schools to global challenges?

METHODS

The Italian community building proceeds from the *Climademy Community Building Support Mechanism Guidelines* (Bellentani, Martinelli, 2023). It kicked off in November 2023 with a 4 days residential and blended workshop attended by 35 lower and upper secondary school teachers with both scientific and humanistic backgrounds and University of Bologna and Fondazione Golinelli representatives. It was a foundational, engaging and motivating event from a personal and professional point of view. It was designed to co-define the purpose, values, and the identity we stand for, and the kind of experiences, practices we want to promote, produce, share.

The process went on through several online and residential meetings, individual and group teachers training (including Climademy international mobilities), teachers' experimentation with local colleagues and students, synchro and asynchronous feedback and sharing. Currently, this process has engaged 32 teachers.

RESULTS

Beyond the educational and training materials produced and the teachers' improvement of skills and ability, the results of the Climademy Italian hub are also the development and experimentation of 1. tools to facilitate groups in which one can contribute individually but collectively (Lipmanowicza and McCandless, 2014, Manzoni and Ossani, 2024, Knapp et al., 2022, Gray et al., 2021) 2. tools and processes to start and manage teaches communities of practice interested in climate change (Maineri, 2023)

These results will be the subject of the workshop, which will be organized in 3 phases:

1. presentation of the tools designed and tested by FG during meetings with Italian teachers and results;
2. experimentation in small groups of some tools to promote a reflect on what kind of communities of teachers the participants want to encourage in their own contexts;
3. meta-reflection activity on the experience carried out.

The GreenComp framework (Bianchi et al.,2022) and the Climademy Competence framework (Taurinen et al., 2025), including the co-designer teacher's role, will clearly be a starting point to frame the common values of our communities.

CONCLUSIONS

Promoting a community of practice means to design spaces and ways of communication among participants, structure interactions to encourage democratic participation of all members and to encourage listening, mutual positive feedback, and personal growth through the exchange of experiences.

ACKNOWLEDGEMENTS

All the Italian hub teachers, especially those of Scuola delle Idee Marino Golinelli (STEAM secondary school) of Bologna; Liceo Scientifico e Musicale "A. Einstein" of Rimini (Italian associated partner); Istituto Tecnico Agrario Chimico Scarabelli Ghini of Imola; Liceo Leonardo da Vinci of Casalecchio di Reno Bologna; IIS "Baracca" of Forlì, Educandato Statale Setti Carraro of Milan, IIS Corinaldesi Padovano of Senigallia, IIS Galilei Ostiglia and Liceo Fermi of Mantova, IIS. G. Vallauri Fossano of Cuneo.

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DOES THE LETTUCE SALAD BREATHS INSIDE YOUR FRIDGE:

VISUALIZATION OF RESPIRATION AND PHOTOSYNTHESIS IN PHYPHOX APP

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Keywords. CO_2 production, CO_2 sequestration, plants, Phyphox

INTRODUCTION

The 13th of the 17 UN Sustainable Development Goals is about action on climate change and its impacts. The increase in the carbon dioxide content of the atmosphere is considered to be one of the important factors for climate change. It is, therefore, important to develop educational activities on the properties of carbon dioxide, and the physical processes that cause its release and sequestration. In this paper, a device for recording the atmospheric carbon dioxide content consisting of two parts is presented. The first part consists of a sensor connected to an Arduino nano 33 BLE microcontroller. The second part is a mobile device (tablet, smartphone) on which Phyphox application is installed. Phyphox application is a free and open-source mobile device application (smartphone and tablet) that can get the data retrieved by the sensors that mobile devices use (Stampfer et al, 2020). It was created by the Technical University of Aachen for educational use and translated into Greek by the author of the article, who is also its ambassador in Greece. Phyphox application can be connected to external sensors, a feature which was exploited in the context of this paper. This constructed device works as a low-cost data logger that records and visualises the changes in CO2 concentration in the form of a graph in real-time. (Chalkiadakis and Sgouros, 2023).

This device was awarded at the national competition and presented at the 2024 European Science on Stage Festival in Turku, Finland.

PHOTOSYNTHESIS, RESPIRATION AND CO2

Understanding cellular respiration and photosynthesis is fundamental to understanding the function of life on Earth as both processes are the basic biochemical pathways through which organisms produce and consume energy. Cellular respiration is the process by which living organisms convert the chemical energy of nutrients, such as glucose, into adenosine triphosphate (ATP), the main form of energy used by cells. Cellular respiration takes place in all living cells, whether plants, animals or microorganisms and ensures that organisms can harness the energy stored in their nutrients (Kapsalis et al., 2014).

Photosynthesis is the process by which plants, algae and some bacteria convert solar energy into chemical energy. It is energetically the reverse of cellular respiration as it is the process by which the chemicals that store energy (nutrients) are created. Through photosynthesis, carbon dioxide and water are converted into glucose and oxygen, essential for the survival of photosynthetic organisms and life on Earth in general. Photosynthesis not only provides the energy that plants need to grow but also produces the oxygen necessary for aerobic organisms to breathe. It also creates the basis of the food chain, providing energy to all ecosystems. Photosynthesis removes carbon dioxide from the atmosphere and stores it in plants, while cellular respiration releases it back into the atmosphere, which makes the aforementioned processes inverse in terms of the production of CO2 gases. The burning of fossil fuels and deforestation have disrupted the natural carbon cycle, leading to increased carbon dioxide levels in the atmosphere, thus exacerbating the greenhouse effect.

DEVICE DESCRIPTION

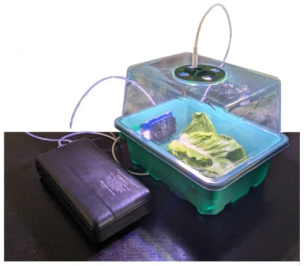

Figure 1. The device powered by a power bank

The device (fig.1) consists of the following elements:

A. A seed starter box.
B. A carbon dioxide sensor mounted inside the box.
C. A microcontroller connected to the sensor. The microcontroller costs between about 50 euros for an Arduino nano BLE to less than 20 euros for an ESP32 microcontroller. It is used to collect the sensor data and send it via bluetooth to a mobile phone or tablet device.
D. Data transmitted is captured by the Phyphox app, installed in a mobile device.
E. An appropriate program (sketch) is needed to be uploaded to the microcontroller. Furthermore, we need to configure the Phyphox application to receive and present the data correctly. Details can be found at: https://tinyurl.com/CO2Device

The total cost is about 150-180 EUR while the cost of similar devices by companies producing educational laboratory equipment is a multiple of the above amount.

DIDACTIC USE

If we place a small plant (e.g. small lentil shoots) or even cut leaves of a plant in the box, we can see the two basic functions of photosynthesis and respiration from the changes in carbon dioxide concentration recorded by the sensor and displayed on the screen of the mobile device. Inside the box, the functions of cellular respiration and photosynthesis occur simultaneously. By closing the lid we can record the changes occurring in carbon dioxide in the isolated environment of the box. Indoors carbon dioxide production due to cellular respiration predominates over photosynthesis so we will observe an increase in carbon dioxide However, if we turn on the LED lights that the box has, then the rate of photosynthesis increases increasing the capture of carbon dioxide and therefore we will observe a decrease. As the average temperature of the earth is correlated to the greenhouse effect and this in turn is largely due to carbon dioxide it is important that with such a simple device we can show capture and release in the short time span of a teaching hour. After discussion, students can interpret the seasonal variability of the gas by referring to the change in light energy reaching the Earth from the Sun.

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STORIES OF CHANGE: DATA, EMOTIONS AND THE CLIMATE CHANGE

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Keywords: Data Literacy, Complexity, Climate Change Education, Emotions

INTRODUCTION

Climate Change is one of the main challenges for the future and, as teachers, we feel obliged to do something in order to become facilitators to guide our students. Being aware of the high quality of Golinelli education and STEAM masterclass, we decide to join the Climademy Training in November 2023 and to become co-designers in the Climademy Network. In this training, different perspectives caught our attention: data visualisation, GreenComp framework, teacher network with high motivation, complexity definition and so on…

Our journey began with a citizenship and civic education activity named “Disaster”. Afterwards, one of us joined the Climademy Summer School held in Marathon in July 2024. During the Summer School, we developed our competences trying out new tools and points of view.

We organised two brand-new educational and teaching paths: one for students and another for teachers. Both our paths involve the four keywords we highlighted before such as Data Literacy, Complexity, Climate Change Education and Emotions.

CLASSROOM ACTIVITY

The first activity, carried out in May 2024, was a civic education program designed for high school students around 14/15 years old. Titled “Disaster,” it refers to the overall theme: the consequences of climate change on our planet. The main aspects we developed in this activity are: Climate Change Education, use of AI, mitigation and roleplaying.
First, climate change education, we began with the use of the Mentimeter software; this activity served as an icebreaker and helped to visualize the students’ thoughts. Next, we examined a real-life example of an ecological disaster before moving on to the creative part. Using AI, the students had to create scenarios in which an ecological disaster occurred due to climate change. With the help of AI, they then had to search for solutions to the problem—a process known as mitigation- involving also the biomimetics that learns from nature. It was crucial to use AI correctly through appropriate prompts. Finally, through a role-playing activity, the students presented their work by creating videos and assuming roles (journalists, activists, scientific experts, and more). This last part was carried out by providing each group with a guiding sheet.

The second activity is titled DatiClima360, aimed at students between 16 and 19 years old. The four keywords that guided our process were: Exploring, Analysing, Data Visualisation Tools and Act.
We started with ice-breaking activity: the snowball battle. We continued then with two exploratory activities, both carried out at the Summer School in Marathon. In the first, we discovered and analysed the emotions linked to climate change. Afterwards, we used the ClimateFresk activity to understand the complexity of climate change: from the causes, to the effects, to adaptations and to the actions needed to mitigate it. This activity was conducted using five decks of cards, to be ordered by cause-effect sequence.

In the second phase, we analysed rainwater samples in the school's chemistry lab and collected data on the pollution present in our area. Additionally, we prepared an oscillating reaction as a tool to visualise and observe the concept of complexity. In the third part, we provided useful data visualization tools such as DataWrapper and Flourish. Finally, the students designed a poster featuring good practices that individuals can adopt in their daily lives to counter climate change.

TEACHER TRAINING

In the teacher training activity, we decided to include a series of tools and methodologies useful for climate change education. We revisited the activities on emotions and on the ClimateFresk we described above. We explained the importance of Data Literacy—how data can be used, how to create one's own dataset, and which tools we can use to visualize data. In addition to DataWrapper and Flourish, we also presented GapMinder, IPCC data and the Interactive Atlas as useful resources. We delved into the concept of complexity and connected it to climate change. Finally, we covered storytelling by revisiting several approaches to addressing the issue of climate change in the classroom. In this last section, we proposed activities related to AI, such as the one written above, one focused on the concept of creative destruction and a last one about sceneries and missions.

CONCLUSIONS

Concerning our classroom and teacher activities, we received overall positive feedbacks from self-assessment questionnaires, highlighting the high engagement both for students and teachers. The activities were designed in order to urge students to take actions addressing climate change.
Teacher training in Bologna, summer school in Marathon, our new Italian Hub community and the overall Climademy project were all valuable inputs that increased our knowledge and skills on Climate Change Education.
Furthermore, we build an interdisciplinary team, finding out common goals between different classes, such as economics and chemistry courses.

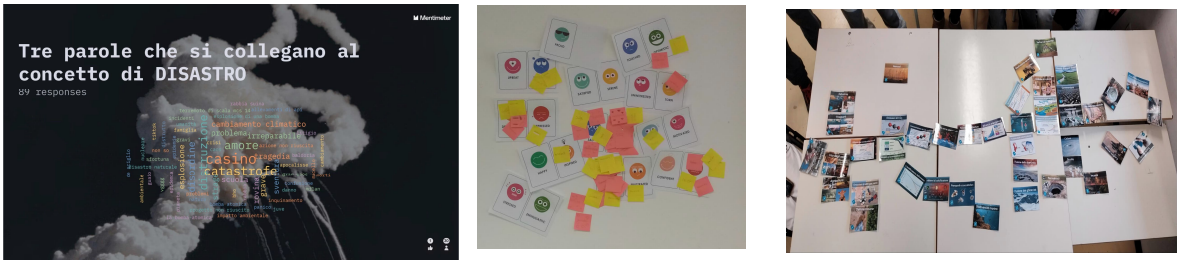

Figure 1. On the left, the World Cloud obtained by Mentimeter: "Three words thinking about Climate Change". In the centre, our Emotions Map. On the right, an example of Climate Fresk session.

ACKNOWLEDGEMENTS

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TESTEd: INTEGRATING SUSTAINABILITY INTO TEACHER EDUCATION

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Keywords: Sustainability Education, Teacher Education, Design Thinking, Open Educational Resources.

INTRODUCTION

The EU-funded Erasmus+ Teacher Academy TESTEd project (Towards a European Syllabus in Teacher Education) addresses the evolving challenges in education by integrating sustainability, digitalization, and democratic education into teacher education. This presentation highlights the project's international lecture series and maker space format, which was implemented as a 5 ECTS course in the participating universities.

Using design thinking as a central framework, the course brought together academic experts, in-service teachers, and a diverse cohort of international student teachers. Participants explored key emerging topics for sustainability, including embracing complexity, bridging the knowledge-action gap, and envisioning possible sustainable futures. During the closing workshop, they collaborated to create Open Educational Resources (OERs) on these themes, which have been published as part of the TESTEd project outcomes.

The lecture series provided a strong theoretical foundation on sustainability, while the maker space workshops enabled hands-on, collaborative approaches to translating theory into practice. By leveraging design thinking, participants engaged in iterative processes of problem-solving and innovation, contributing to their professional development and enhancing their ability to address sustainability in diverse educational contexts.

This course format exemplifies how higher education institutions can respond to global challenges by equipping educators with practical tools, fostering critical thinking, and promoting interdisciplinary collaboration. The TESTEd project’s outcomes highlight the importance of international cooperation in teacher education, particularly in preparing future educators to navigate and address the complexities of sustainability education.

CLIMATE CHANGE EDUCATIONAL ACTIVITIES IN NATURAL AND CULTURAL GEOSITES THROUGH THE USE OF GEONFORMATIC TOOLS AND METEOROLOGICAL DATA

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Keywords: Meteorological Phenomena, Cultural Heritage, Geoinformatics, Inquiry Based Learning

INTRODUCTION

In the context of strengthening the interdisciplinary nature and the connection of different teaching subjects with the aim of cultivating skills in students, the current educational system promotes the study of meteorological phenomena and climate change. Meteorological phenomena and their analysis are at the center of study of the educational community as the consequences they have on the anthropogenic and natural environment constitute an important issue to be investigated in the context of educational reality. A basic aim in this context is the cultivation of resilience in students and a deeper awareness of the consequences of climatic phenomena, which is closely linked to the United Nations sustainable development goals.

Two educational proposals were designed as activities related to meteorological data, using tools from the science of Geoinformatics and the corresponding geodata to raise awareness of climate change among students in primary and secondary education degrees.

The first educational activity proposal concerns geoinformatics tools that are available for free on the internet with the corresponding geodata and contribute to the understanding of meteorological phenomena that take place in relation to cultural heritage in Greece. Through the technique of the collaborative assembly method (jigsaw), analysis, processing and collection of data from geographic databases related to meteorological phenomena is carried out.

The second educational activity proposal takes the form of a project on meteorological phenomena that affect geosites in Greece and around the world. Students, through groups based on playful interactive activities regarding the analysis, comparison and processing of geodata within the framework of guided inquiry-based learning, draw conclusions and seek solutions in the context of achieving resilience.

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NARRATIVE THINKING FOR CLIMATE CHANGE EDUCATION: RESULTS FROM A PILOT STUDY

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Keywords: Climate Change Education, Narrative thinking, Uncertainty, Sensemaking.

INTRODUCTION

The pressing challenges posed by the Climate Change (CC) crisis call for innovative educational strategies to address its multifaceted challenges. Among these, narratives have emerged as powerful pedagogical tools, widely recognized for their ability to facilitate scientific understanding while simultaneously engaging learners on both emotional and cognitive levels (Avraamidou & Osborne, 2009; Hulme, 2009). Recently, increasing scholars are moving the focus from narratives as communication tools to narratives as fundamental cognitive structures that shape human understanding and decision-making (Bruner, 1986; Goodchall, 2012; Fletcher, 2023; Norris et al., 2005; Soares et al., 2023). This study is grounded in Bruner's dual modes of thought theory (1986), according to which, human cognition operates through two irreducible yet complementary modes: narrative and paradigmatic thinking. Each provides a distinct yet equally valid means of making sense of the world—narrative thought prioritizes action, temporality, and the verisimilitude of human experience, whereas paradigmatic thought is characterized by logic, abstraction, and empirical verifiability (Bruner, 1986). But what does it mean to employ narrative thinking in the context of CCE? A key challenge in answering this question lies in the significant conceptual ambiguity surrounding the term "narrative." Its definition and application vary widely across disciplines, often encompassing a broad spectrum of meanings and artefacts (D'Orto & Tasquier, 2025). To bring clarity to this issue, we proposed a theoretical framework grounded in the literary concept of "narrativity" (Ryan, 2005). By identifying a structured set of core narrative features—such as temporality, events, and genre—we designed a four-layer tool (D'Orto & Tasquier, 2025) to characterize different forms of CC narratives and link them to specific narrative thinking skills.

This study emphasizes narratives' function to shape and foster a specific mode of thinking. This perspective is particularly valuable for CCE, where learners must not only grasp complex scientific data but also develop a sense of agency, ethical reasoning, and future-oriented thinking. Many existing educational approaches either emphasize scientific accuracy while neglecting emotional engagement or focus on storytelling at the risk of oversimplifying complexity. The aim of the tool is to help designers avoid those simplistic approaches, ensuring that narratives are not only engaging but also aligned with cognitive processes that support deeper learning.

This contribution presents how the narrativity tool was employed to analyse and redesign an existing scenario-making activity on climate change impacts and drivers, called F*you*TURES (De Zuani et al., 2024). The revised version of the activity was implemented over the third day of CLIMADEMY Summer School held in Bologna from 26th to 29th June, 2024, and it was tailored specifically for teachers and researchers.

METHODS

This study adopts a design-based research (DBR) approach (Cobb et al., 2003), which integrates the design of educational artefacts with research on learning in both the designed and implemented settings (Juuti & Lavonen, 2006). DBR is characterized by an iterative cycle of design, implementation, analysis,

and refinement, ensuring that educational interventions are both empirically grounded and adaptable to real-world contexts. In our case, the study followed the following phases: Literature review and framework development, pilot study (design and implementation), first data collection and analysis, refinement of the framework, new course (design and implementation), second data analysis and final refinement of the framework. The pilot study presented in this study was based on the analysis and re-design of the F*you*TURES activity based on two main guiding concepts derived from the literature, and served as a first test for the framework in practice. Insights from the analysis of the pilot's data guided the refinement of the framework and the development of a set of design principles, ensuring empirical validity. These refinements informed the design of a 12-hour course, currently ongoing and whose data analysis will bring further refinement to the framework, continuing the DBR cycle and ensuring adaptability and effectiveness in Climate Change Education (CCE).

The core of the original F*you*TURES activity focuses on developing systemic thinking through the constructions of scenarios, following and using a simulator (EN-ROADS) developed by Climate Interactive and MIT (Chikofsky et al., 2024). The activity is designed to engage learners with the three different types of uncertainty in relation to Climate modeling, as defined by Shepherd et al(2019):

- Reflexive uncertainty: uncertainty in the role of humans in future climate forcing;
- Epistemic uncertainty: uncertainty in our knowledge of how climate will reply to the forcing;
- Aleatoric uncertainty: uncertainty in the actual realization of climate for a particular time window.

The pilot activity designed a narrative-enhanced version, in which we paired the original activity with a new narrative layer designed to foster narrative thinking at a higher layer of narrativity (D'Orto & Tasquier, 2025) to scaffold sense-making, imagination and ethical reasoning and value-laden engagement. The re-design of the activity involved creating a narrative frame to support a role-play experience, developing sub-activities in the form of socio-economically enhanced reports to stimulate students' narrative imagination through socio-economic key areas of SSPs narratives (O'Neil et al., 2017), and designing a final sub-activity to help teachers and researchers synthesize the activity's reflections into a concluding narrative, presented as a "mockumentary-style interview."

RESULTS

Learners, although not formally instructed in this regard, naturally employed narrative thinking skills to reframe and make sense of uncertainty—one of the central themes of the F*you*TURES activity. More specifically, the narrative frame and the mock-interview format encouraged them to engage in imaginative speculation, emotional perspective-taking, and causal reasoning,allowing for a deeper exploration of the three different types of uncertainty addressed in the game (Shepherd et al, 2019). Those three types of uncertainty, developed within the CC scenario-modelling community, in a narrative mode of thinking become the perspective of the scientific community. An analysis of the mocku-style interviews produced by students showed that during the new implementation they were able to use two specific narrative skills, perspective taking and the interplay between physical/mental landscapes. Bruner distinguishes between the landscape of action (the realm of physical events) and the landscape of consciousness to explain how we construct meaning from experience. The landscape of action refers to measurable, objective phenomena, such as rising temperatures, increasing extreme weather events, and sea-level rise. The landscape of consciousness, on the other hand, involves how humans interpret these events, embed them in narratives, and assign meaning to them. As shown by some specific extract of the report and mockumentary style interview scripts, those narrative thinking skills helped participants making sense of those types of uncertainty as follow:

- Epistemic uncertainty: limitations in individual's knowledge, due to the inherent complex and interdisciplinary nature of CC;
- Aleatoric uncertainty: inherent unpredictability of events, including how climate outcomes unfold over time due to political and personal adaptation to contingencies;

- Reflexive uncertainty: uncertainty in future human actions in relation to values, intentions, and choices.

CONCLUSION

The narrative-enhanced approach demonstrated potential for strengthening learners' capacity to integrate scientific reasoning with human-centred, value-laden reflections, essential skills for navigating complex socio-environmental challenges through the employment of specific narrative thinking skills. More specifically, perspective taking helps learners see CC from multiple angles, understanding the motivations, constraints, and values that drive different actors—scientists, policymakers, citizens, businesses, and vulnerable communities—as well as how each perceives and responds to uncertainty. Additionally, the interplay between physical and mental landscapes highlights the complex role of uncertainty in shaping political and personal decision-making across these perspectives.

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HOW CAN WE TEACH VALUES IN CLIMATE CHANGE EDUCATION? A BRIEF INTRODUCTION TO THE THEORY OF BASIC VALUES AND EDUCATION FRAMEWORKS.

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Keywords: Values, Climate change education, Teacher professional development.

INTRODUCTION

Values in climate action is an emerging topic, particularly, in climate change education. Important sustainability competence frameworks, such as the OECD Learning Compass 2030 (OECD, 2019) and the GreenComp (Bianchi et al., 2022) refer to values as competencies, essential to achieving global sustainability goals. While it is known that there is a values-action gap in climate action, values seem to be a key component when combined with other elements (Cantell et al., 2019). Schwartz (1992) introduced a comprehensive set of basic values that are recognized and similarly structured in all societies. Reflecting on both how values are organized and peoples' perception of their values, may also influence peoples' decision-making on how to act towards climate change. When such reflection is proposed to teachers as part of their professional development, it can create room for re-thinking their practices and develop the supporting conditions to enable pupils' climate competencies.

METHODS

A Values in Climate Change Education workshop was designed with the purpose of 1. Promoting individual reflection about climate change values, and 2. Promoting discussion among educators on how to embed climate change values into teaching practices. This workshop consisted of a brief introduction to the theory of basic values (Schwartz, 1992, Schwartz et al., 2012), contextualized to climate change education in Finland. Two well-known frameworks were used as background, together with the Finnish National Core Curriculum for General Upper Secondary Education, (Finnish National Agency for Education, 2020). The workshop was piloted with the CLIMADEMY teachers from Finnish schools in 2024 and modified based on feedback. In January 2025, the workshop was implemented during a CLIMADEMY event at the University of Helsinki. The target audience was teachers, researchers and educators interested in climate change education. Before the workshop, participants were assigned an individual written reflection. After the workshop, focus-group interviews were conducted. Data was transcribed and translated from Finnish to English and will be further analysed with the Atlas.ti software.

RESULTS

Preliminary results showed that teachers did not have ready models on how to address climate change values in classroom teaching. However, teachers recognized the importance of supporting learning and reflecting on values during teaching. Creating space for discussion on values in the communities of practice was also emphasized by teachers. As data collection and analysis are ongoing, additional results and refined insights should be presented at the conference.

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INTEGRATING HANDS-ON CLIMATE CHANGE EDUCATION WITH THE PEDAGOGICAL MODEL OF CLIMADEMY: A GREEK HUB'S APPROACH TO CLIMATE LITERACY

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Keywords: Climate literacy, hands-on learning, scientific inquiry, climate action.

INTRODUCTION

Climate change presents one of the most urgent challenges of our time, with profound effects on ecosystems, human livelihoods, and global health. Addressing these challenges requires not only the advancement of scientific knowledge but also the cultivation of a deeper connection between knowledge, values, and action. The proposed educational program from the Greek Hub aims to meet this need by integrating innovative methodologies into secondary education, emphasizing both scientific literacy and value-based learning.

METHODS

This educational initiative originated from the national project *Edu4Clima*, which primarily targeted students and served as a foundational effort in fostering climate literacy. Building on this groundwork, the program continues to evolve, based on the feedback from both students and teachers. At the core of the program is also the CLIMADEMY pedagogical model, which integrates the cognitive, psychomotor, and affective domains of learning to cultivate knowledge, skills, and attitudes (Levrini, 2025).

1. **Integration of Values in Learning**: Core values such as environmental sensitivity, empathy for future generations, and collective responsibility are integrated into scientific inquiry, helping students consider the ethical and social impacts of climate change and their role in building a sustainable future.
2. **Scientific Experiments and Inquiry**: Students engage in hands-on experiments that simplify complex climate phenomena. Activities include investigating the composition of the atmosphere, the greenhouse effect, the ocean acidification, the thermal expansion of seawater, the melting of the ice, the albedo effect, the ocean currents, and the heat capacity of water. These experiments provide practical insights into the mechanisms driving climate change and its impacts and reinforce the scientific method. Additionally, students collaborate with the scientific team from the Finokalia atmospheric monitoring station, analyzing real-time data on CO_2 levels and climate trends to enhance their understanding of climate science.
3. **Envisioning**: Students approach climate-related problems by making hypotheses and generating ideas to address issues such as reducing their ecological footprint. These activities foster critical thinking and encourage innovative perspectives on mitigating the impacts of climate change.
4. **Action and Dissemination**: Upon completing the program, students become “climate ambassadors” within their schools and local communities. They present their findings, organize awareness campaigns, and encourage peers and families to adopt sustainable practices. For example, participating schools have organized local climate action days, showcasing the students’ commitment to driving change within their communities.

RESULTS

The program has reached over 1.000 students across Crete, with preliminary evaluations indicating significant improvements in students' understanding of climate phenomena, critical thinking skills, and motivation to take action. In 2024, over 80% of participants reported feeling more prepared to engage in climate action. Teachers play a pivotal role in guiding students and aligning activities with curriculum standards while extending their impact beyond the classroom.

CONCLUSIONS

By integrating values and scientific inquiry, this program fosters a holistic understanding of climate change, bridging the gap between knowledge and personal responsibility. It equips students with the tools to address climate challenges creatively and collaboratively, while inspiring them to become active agents of change in their communities.

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SUSTAINABILITY IN TEACHER EDUCATION – DEVELOPING A DIGITAL LEARNING MODULE ON SUSTAINABILITY EDUCATION FOR PRE- AND IN-SERVICE TEACHERS

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Keywords: Sustainability education, Pre-service teachers, In-service teachers.

INTRODUCTION

Education plays a key role in worldwide efforts to address the global sustainability crises. In European teacher education there is a burning need for materials and competencies in sustainability and sustainability education. In the TEFF Teacher Academy, sustainability was recognized as one of the four skill areas of transversal futures literacy. The sustainability skills area in TEFF refers to the GreenComp framework developed by the European Commission (Bianchi et al., 2022). In recognizing the need for further development of sustainability and sustainability education competences in teacher education, TEFF planned and developed a Digital Learning Module (DLM) on Sustainability Education. The DLM aims to advance the needed sustainability competencies among European teachers. The DLM was produced by University of Helsinki (Task Leader), Oslo Metropolitan University (Work Package Leader), University of Cologne (Project Coordinator), University of Murcia, KU Leuven, University of Florence, Nantes Université, Saxion University of Applied Sciences, and Utrecht University. The presentation will describe experiences of how the digital learning module on sustainability education was planned, designed, implemented, and launched.

METHODS

The development of the DLM was initiated through a needs analysis of existing materials and educational offers on sustainability skills at the TEFF partner institutions. Simultaneously, necessary sustainability skills and competences of pre-service and in-service teachers across Europe were identified. These were mapped in Spring 2024. Through this mapping, the TEFF partners analysed the need for a novel digital learning module on sustainability to be offered for European pre-service and in-service teachers and teacher educators. The DLM was to be created based on prior expertise and resources available in partner institutions and would follow the structure indicated in Table 1, consisting of three submodules.

Table 1. Sustainability Education Digital Learning Module Contents & Structure

Module / Intended Learning Outcome	Core contents	Assessment methods
Module 1. The student is able to recognize sustainability as a complex and multifaceted concept	Strong/weak sustainability, different frameworks of sustainability	Multiple-choice questionnaire, Pre-post mind map activity, self-evaluation questionnaire
Module 2. The student is able to identify different frameworks and approaches for sustainability education	Different frameworks of sustainability competences & education	Multiple choice questionnaire
Module 3. The student is able to plan a constructively aligned learning activity to address sustainability education	How to implement sustainability education	Learning activity planning, Self-evaluation questionnaire

RESULTS & CONCLUSIONS

At the time of submission to the ClimAdemy Final Conference, the first of three submodules has been launched. By the conference, TEFF aims to have all three submodules launched, piloted, and implemented

for in-service and pre-service teacher education among partner institutions. The DLM will also be disseminated beyond the TEFF consortium. It provides an open educational resource for institutions and associations in the educational sector, as well as for individual teachers, teacher students, and teacher educators. The presentation at ClimAdemy Final Conference will cover the TEFF Teacher Academy's experiences creating a Sustainability Education DLM from the needs analysis to the planning and creation stages, to piloting and finally implementing the full module within teacher education institutions across Europe and beyond.

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CLIMATE CHANGE TEACHERS' ACADEMY (CLIMADEMY)
THE ERASMUS+ TEACHERS' ACADEMY FOR CLIMATE EDUCATION

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Keywords: Climate Change, Teacher's Academy, Hubs

INTRODUCTION

Climate change is unequivocally attributed to human activities and is already affecting Europe, leading to heat waves, extreme drought and flood events, forest fires, biodiversity loss, decreasing crop yields and affecting human health. There is an urgent need for immediate actions to mitigate climate change. Each individual and the society as a whole need to change behavior and take actions for sustainable development, preservation of the environment, mitigation and adaptation to climate change. This requires societal changes that rely on engagement of young people, therefore, central to the success of humanity's transformation is young people's education.

The goal of the CLIMADEMY Erasmus + project is to provide a thorough training framework on climate change, its causes, effects, and mitigation strategies for both practicing and student teachers. Through a community of practice and network, CLIMADEMY facilitates the establishment of creative professional development techniques and programs addressed to serving and learning teachers aiming to support Teacher's professional development within Europe on the topic of climate change and its impacts. CLIMADEMY is a Teachers' Academy, which has been established through four hubs in different countries that are supported and connected by a common platform with a virtual Climate Auditorium (CLAUDI). The initial network consisted of 200 trainees from around Europe who participated in this Academy over the course of two years through online, in-person, and blended learning. CLIMADEMY teachers discuss, support each other and develop new educational material and training approaches to learn about climate change. The educational material targets climate change drivers, impacts and adaptation and mitigation options and is made available on the CLAUDI platform. CLIMADEMY's Network started with a small number of pilot teachers from each country who are co-designers and trainees, that act as the seed for engagement of a continuously increasing number of teachers.

METHODS

A partnership including seven partners (universities and public entities) from four European countries (Greece, Italy, Germany and Finland) was established to carry out the aforementioned goal of the

CLIMADEMY project. There have been five stages to the project. Initially, a thorough survey of currently available educational resources and a study of the literature on climate change and climate change education was carried out. During the second phase, a community of practice of teacher educators, seasoned environmental scientists, and researchers in science education was formed by twenty teachers from the participating organizations' home countries. The Teachers' Academy was formed with each participating nation hosting one of the four hubs. Furthermore, a single repository and virtual platform (Climate Auditorium, CLAUDI) has been created and continuously been updated. The first twenty teachers from the community of practice acted as mentors for hundred serving teachers in the third phase. These working educators participated in teacher-learning events like training sessions and summer schools. A hundred student teachers also received training at their national hubs and are encouraged to participate in ERASMUS-sponsored training at other hubs in addition to the serving teachers. During the final phase, the Academy is accessible to all teachers in Europe (with a goal of 2000 teachers by the program's conclusion).

RESULTS

The National Hubs. Four national educational hubs have been established within the project. Two of them are in connection with air pollution and climate change monitoring stations in two different regions of Europe that experience exceptionally rapid climate changes when compared to the global mean trends: one close to the Arctic region in a boreal forest in Finland and the second one in the Mediterranean semi-arid subtropical region in Greece. Two more hubs have been established focusing on computer modeling and space-based observations of the Earth system in Germany and the pedagogical foundations of environmental education in Italy. Hyytiälä forest field station is hosting the **Finnish Hub** and is available for national and international visits and provides the teachers and students with a different view of the forest under climate change. Activities at the Finnish Hub aimed to equip students and teachers with useful tools for future teaching, taking into account the challenges posed by the climate crisis. Expert lectures related to the Hyytiälä Forest Field Station and the SMEAR II research station (Station for Measuring Ecosystem-Atmosphere Relations) are provided. The Finokalia observatory of the University of Crete and its surrounding facilities at Nofalia school in Lasithi, Crete, is hosting the **Greek Hub** where teachers and students are introduced to climate change issues with focus on the Mediterranean and are guided in the research and educational activities of the station as well as in local practices of adaptation to climate change. The **German Hub** is hosted at the Institute of Environmental Physics where the teachers have the opportunity to see miniatures of satellites and the state-of-the-art instruments they have onboard to observe Earth's environment and be introduced to satellite observations and numerical climate modeling. The **Italian Hub** hosted by Fondazione Gollinelli and the University of Bologna provides experiences combining the consolidation of basic scientific skills (on drivers, impacts and mitigation measures), with an active, constructivist and steam pedagogical approach mainly working on: future literacy, uncertainty and complexity, data literacy, storytelling, civic education and active citizenship. All Hubs provide activities to familiarize in-service and student teachers with university research stations and the available open data that can be utilized in teaching of climate change. Through physical, virtual (supported by CLAUDI) and blended training, the hubs provide informal learning settings that can aid teachers in thinking differently about the practice of school science with respect to climate change.

The Central Platform. CLAUDI is the Academy's platform that supports an effective community building and helps all involved teachers to prepare, adapt and enrich their teaching activities with new material and activities by thinking out of the box for climate change education. CLAUDI makes available all educational material prepared in CLIMADEMY. It is structured so that each national hub has its domain, containing material not only general on global climate change but also specific to the country's issues. Therefore, users from each country may find information relevant to their geographical, cultural and linguistic context easily. CLAUDI additionally offers the user the option to browse its content based on thematic criteria and access additional material. CLAUDI can be accessed through the Academy's website https://climademy.eu (ENTER CLAUDI) or directly at https://claudi.chemistry.uoc.gr and all material is openly available after registration. The available material is in the four languages of the

partner countries (Italian, Finnish, Greek, German) and English.

The Competence Framework. A Competence framework has been developed in CLIMADEMY for teaching climate change in schools.

Fig. 1. The CLIMADEMY Competence model

This framework is the bedrock of all the teaching activities of our Academy and 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.

The Pedagogical Model. CLIMADEMY focuses its efforts to address the teachers' needs based on open-ended resources. The multi-dimensional pedagogical model that has been developed within CLIMADEMY aims to support teachers in teaching activities development in order to generate a new school interdisciplinary ecosystem and promote their efficiency in teaching and learning about climate change. In particular, it is developed based on co-design and co-learning to enrich and improve teachers' knowledge, to redefine teachers' sense of expertise and in parallel to be concrete but flexible. The pedagogical model questions institutional barriers among disciplines and guides instructional choices based on goals and shared values and requires a school system that is supportive and socially responsive. The pedagogical model development is led by the University of Bologna and is presented in detail by Levrini et al. (WCPE, 2025).

International Training activities. Several virtual workshops took place to disseminate CLIMADEMY goals and activities, introduce the co-designers teachers to the spirit of the Academy and support them in the development of educational activities for their school classes. In the following we present the 2024 series of in-person and hybrid international workshops that took place at each Hub.

The Greek Hub organized two major international training activities: The International Summer School of Climademy conducted by Ellinogermaniki Agogi in Athens, Greece, from 30 June to 3 July 2024. The Course was designed for teachers to explore methodological, theoretical, and practical aspects, challenges, needs, and possible solutions to the difficult task of explaining the complex issue of climate change, in an interactive way through peer learning activities. An international Autumn School took place in Agios Nikolaos, Crete, from 3 to 5 November 2024 and included lectures and experiential activities for teachers of all levels of education so that they would become familiar not only with the scientific concepts of Climate Change but also with pedagogical practices that can help them to transfer these concepts to the classroom. During the course, participants were introduced to the project's teaching framework for teaching Climate Change and participated in activities that illustrated the application of this framework in the classroom. These activities took place at the Research and Innovation Hub in

Nofalia/Finokalia, Lassithi. The participants visited the environmental station of the University of Crete in Finokalia to familiarise themselves with the measurements and to get acquainted with the research equipment on which the study of Climate Change is based. They worked on how to manage uncertainties and analyse scientific knowledge for envisioning the future, discussed coping strategies for eco-anxiety, played collaborative games and explored digital tools and inquiry-based activities.

The Italian Hub transformed Bologna into a vibrant hub of innovation, creativity, and collaboration as educators and researchers gathered for the CLIMADEMY International Summer School from 26th to 29th June 2024. Entitled "The Human Side of Data: Teaching Climate Change Through a STEAM Approach," the event offered a unique opportunity to explore how data can inspire action, empathy, and transformative learning. The journey began with the theme of "Data Humanism, Data Storytelling and Sustainability Competencies." Educators dove into interactive workshops that transformed climate data into a journey, connecting numbers to human experiences and real-world actions. Participants discovered creative ways to bring data to life, highlighting its emotional and aesthetic dimensions, inspired by the work of designer Giorgia Lupi. Through hands-on activities, educators explored how human-centric data visualizations can engage students, fostering empathy and understanding of complex issues like climate change. On the third day, the focus shifted to "Future Thinking and Scenarios," where participants used tools like the En-ROADS Climate Simulator and the FyouTURES Game to envision diverse futures. Through immersive exercises, they crafted scenarios shaped by policy choices and societal values, exploring trade-offs and interdependencies. Activities emphasized blending science, creativity, and strategy to address global warming, teaching educators to integrate future-oriented narratives into their classrooms. The event concluded with a STEAM treasure hunt through Bologna, blending data, art, and science to connect the city's culture with climate education, offering a dynamic model for community-integrated learning. Throughout the Summer School, participants not only developed technical skills but also embraced the values of cooperation, creativity, and agency. The summer school fostered a sense of shared responsibility among the teachers.

The German Hub organized an international winter school on "Foundations of climate change, Remote sensing via satellites and using climate models" at the University of Bremen in Bremen from 4th to the 6th of December 2024 with hands-on exercises and conviviality activities relevant to climate change. The workshop introduced the participant teachers and student teachers to the basics of climate change, the basics of spectroscopy and remote sensing, satellite observations and retrievals, and chemistry-transport and climate modeling, including projections. These training sessions placed a strong emphasis on hands-on learning that contributed to understanding the aforementioned topics and provided ideas for developing classroom activities. Participants engaged in interactive activities such as the climate call card game, satellite data stories, and practical applications of climate models, ensuring that the concepts explored could be seamlessly integrated into classroom teaching.

In 2023 and 2024 the Teachers' Climate Change Forum (TCCF) was arranged in Hyytiälä, Finland, as a part of the CLIMAte change teachers' acaDEMY (CLIMADEMY). TCCF has been organized since 2017 by University of Helsinki Science Education, which is part of LUMA Centre Finland, and Institute for Atmospheric and Earth System Research (INAR). It brings together teachers and other educational professionals as well as researchers who are passionate about climate science and sustainability in education. The program includes lectures by researchers in educational as well as atmospheric sciences, hands-on workshops as well as informal communication supporting a teacher – researcher network building and spread of best practices. In 2024 the TCCF workshops focused on using climate data online tools and student action. In October 2024, science teachers from the Otaniemi upper-secondary school traveled to Hyytiälä Forest Station for a 2-day program focused on designing task packages in collaboration with researchers to support climate change education, utilizing the forest as the main subject. Teachers had the opportunity to visit the forest station to understand how climate data is collected, and workshops included tools for climate data analysis and how to approach values in climate education. In 2025 the CLIMADEMY Final Conference is combined with TCCF organized at Hyytiälä Forest Station from March 31 to April 3, 2025.

CONCLUSIONS

CLIMADEMY is a consortium of four countries, climate change researchers and educators, teacher educators, and teachers who contributed as co-designers from the first steps of the project. It collected and developed educational material to support teaching climate change in the classroom that is publicly available on the project platform and climate change auditorium, CLAUDI. It developed to support teacher's professional development and climate change education in schools, it implemented informal training activities at the four national research and education hubs. All hub activities are connected through the central platform CLAUDI. CLIMADEMY has developed a multi-dimensional pedagogical model, a competence framework and tools to support teachers in developing their professional skills and introducing climate change science in the school's curricula. The ambition of CLIMADEMY is to maximize its impact through largely disseminating out of the Consortium, inside and outside Europe, the developed material and frameworks that are presented at international educational and science conferences.

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EMPOWERING TECHNICAL VOCATIONAL EDUCATION AND TRAINING STUDENTS TO TACKLE CLIMATE CHANGE THROUGH DESIGN-BASED THINKING APPROACH IN TANZANIA (Design4Climate Action)

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Keywords: Technical and Vocational Education and Training (TVET), Climate Change, Design-Based Thinking.

INTRODUCTION

Climate change presents a critical challenge that requires innovative and practical solutions (Kosciulek, 2020; UNESCO, 2024). Engaging students in Technical and Vocational Education and Training (TVET) institutions to employ Design-Based Thinking (DBT) approach offers a unique opportunity to harness their creativity and technical skills to address this global issue. Specifically, the DBT approach involves the identification of real-world climate challenges, the ideation, prototypation, testing and implementation of practical solutions relevant to local communities (Rösch et al., 2023).

METHODS

Participatory Design Thinking methodology will be used to guide the execution of this project. This is a collaborative and inclusive approach of involving both TVET trainers and students in designing, implementing, and evaluating the project (Obudho Simon, 2024). Thus, this project will emphasize on the relevance of DBT and the active participation of TVET trainers and students, for creating a collaborative environment where they can feel empowered to act as agents of change for addressing climate challenges in Tanzania. The project aims to empower TVET students in Tanzania to design and develop innovative climate change solutions using a DBT approach. Prior to the design and development phase, the project will evaluate the current knowledge and understanding of climate change and DBT among TVET trainers and students, followed by the co-design of a comprehensive training programme tailored to trainer's and student's needs. Later, the project will equipe trainers with the knowledge and skills about climate change concepts and effective facilitation of DBT processes. TVET students will be trained to apply DBT principles in identifying, analyzing, and addressing real-world climate challenges within their communities and later on be guided in designing and developing innovative, practical, and community-relevant climate change solutions as part of their final-year mini-projects. Lastly, the feasibility and impact of these projects will be assessed, with a focus on scaling successful solutions for broader application across Tanzania.

RESULTS AND DISCUSSION

Executing this project will enable TVET students to develop innovative climate change solutions and enhance their problem-solving, collaboration, and critical-thinking skills. This project is expected to prepare a new generation of Tanzanian professionals equipped to combat climate change and contribute to Tanzania's efforts to achieve national climate change strategies and global efforts, such as the Paris Agreement and SDG 13 (Climate Action).

ACKNOWLEDGEMENTS

This is a work in progress project in which the author is still looking for potential collaborators and financial support to fully put this idea into practice.

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GRAASP CLIMATE: SIMULATIONS TO TEACH THE PHYSICS AND CHEMISTRY OF GLOBAL WARMING IN SECONDARY SCHOOLS

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Keywords: Simulations, Interactive activities, Physics, Chemistry

INTRODUCTION

In times of climate crisis, teaching global challenges such as climate change should be a top priority. Without a basic scientific understanding, future citizens and decision-makers are prone to skepticism and lack the systemic thinking skills to take action.

To achieve this, the Graasp Climate project (climate.graasp.org) creates interactive simulations and activities allowing students to investigate the causes and consequences of global warming in physics and chemistry at middle and schools. The simulations are designed by a team of high school teachers to by aligned with typical school programmes, by mobilizing concepts that are previously taught in these disciplines (electrostatics, atoms and molecules). In particular, our resources are designed to tackle common misconceptions reported in the climate education literature (see e.g. Varela 2021 for a review). The simulations are coded by professional developers from the Graasp association at EPFL.

In this talk, I will present our different physics and chemistry simulations and the associated concepts that students can discover (Emission of radiation in the VIS, IR and UV domain, Thermal IR radiation, Greenhouse molecules and interaction with radiation, Energy budget in a global model, Ocean acidification).

As the simulations can be ran in a browser, we can embed them in web-based activities created with the learning platform graasp.org. Such activities allow scaffolding of student investigations and enable an active learning process that enhances conceptual understanding.

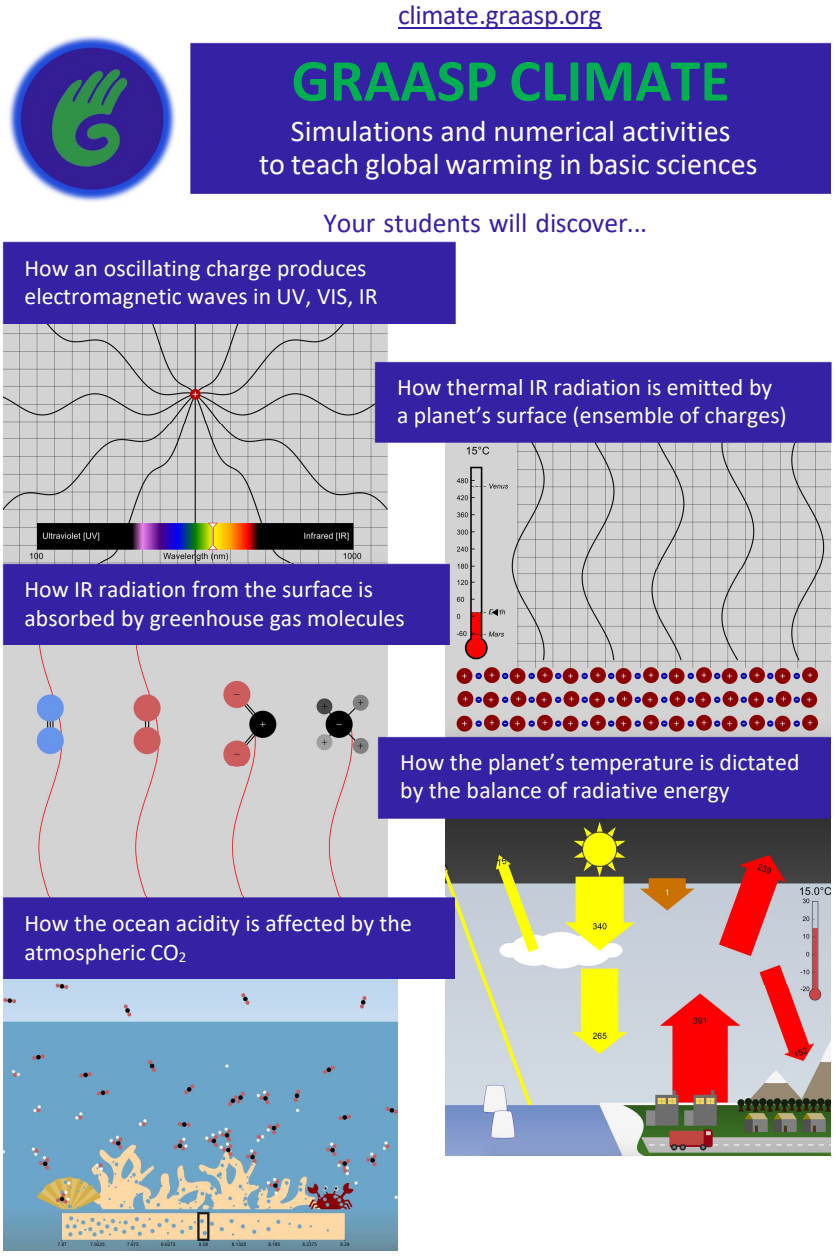

Figure 1. Examples of our five simulations and associated concepts that students can discover.

CLIMATE CHANGE EDUCATION PRACTICES IN LEMPÄÄLÄ UPPER SECONDARY SCHOOL

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Keywords: Climate change education, Climate warriors, Geography, Upper secondary school.

INTRODUCTION

Finnish biology and geography subject teachers have taught climate change (CC) yearly for decades. Over the years, many different pedagogical and didactical methods have been implemented to help learners understand the mechanisms of CC, its consequences, the possible mitigation measures, and, in recent years also adaptation measures. The CLIMADEMY project has highlighted the rare position of Finnish subject teachers, who have CC integrated into the national curriculum for many years. This contribution introduces some of the latest practices in climate change education implemented at Lempäälä Upper Secondary School.

METHODS AND RESULTS

The CLIMADEMY project held various remote and in-person meetings that facilitated the sharing, comparison, and joint development of diverse pedagogical ideas and practices. For example, one proposed activity to maintain engaging climate change education for young audiences is an escape game crafted by Maija Heikkilä, Kaarina Weckström, and Eveliina Tammisto (2022). The game requires no adjustments, as it aligns perfectly with the school curriculum. The game with all its materials is available at the platform https://www.helsinki.fi/assets/drupal/2022-11/Arctic_Climate_Change_pakohuonepeli_lukio.pdf. This game was tested and based on students' and teacher's feedback, it was integrated to a compulsory biology course in ecology and environmental issues as one of the assignments.

A CC teaching package of three lessons in high school geography is available in the project's CLAUDI platform. It is based on the idea of positive recognition (Häkli *et al.*, 2018) in the field of environmental education. It aims to make visible the existing knowledge of young students (experiential and cognitive knowledge, different ways and forms of knowing), that is, what do learners already know about CC/climate refugees, etc. As they work in small groups, they get to discuss not only what they already know but also what they are most interested in and concerned with. In other words, the objective is to clarify how CC appears to the students and how it connects to their lives. Young people learn about each other's different views and understandings in small groups. The key questions for the student groups are as follows: What does CC look like in our world? How can we relate to it in new ways through shared understanding? What can we do about the climate issues we care about? As the final task, they create their own climate utopia or dystopia based on a variety of information sources and present their views to others.

The four dimensions of the CLIMADEMY competence framework (Kanakidou *et al.,* 2023) for teaching CC in schools are applied in Lempäälä Upper Secondary School. Specifically, values and attitudes concerning sustainability cross all the subjects taught and studied in the school. This is stated in the curriculum. Moreover, these values and attitudes are discussed in an extracurricular activity called *the Climate Warriors* that started in 2018. This is the school's most important extracurricular program; as many as 100 of the 450 students participate in it. Understanding one's own values and acting in their direction is considered a competence that will greatly benefit students in their future lives. Also, getting along with people with different values is seen as an important skill.

Furthermore, when the students act as Climate Warriors they engage in discussions on sustainability and search for information about the most pressing issues in small groups. They do this in multiple ways, for example by interviewing university researchers. They process the gathered data into social media posts and posters and disseminate this information to younger students by visiting classes in comprehensive schools. They are well known in the municipality and recently they were asked to comment on the municipality's biodiversity and energy strategies. To summarize, all four areas of the competency model are implemented: a. values and attitudes, b. scientific inquiry, c. creativity, and e. action. These competencies are made visible so that the students perceive the big picture and the great value for themselves. The visualization process is done using the bicycle model of climate education (Tolppanen *et al.,* 2017).

CONCLUSIONS

Recent results connected to CC in different fields of research, such as climate change education, atmospheric sciences and science education, inspired new practices in Lempäälä Upper Secondary School. Pedagogical practices are applied to course plans and extracurricular activities that implement the CLIMADEMY competence framework.

Teachers participated in building a national network that will continue to operate after the project. This cooperation enhances the teachers' sense of hope and equips them to share both knowledge and optimism with our youth.

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TEACHING CLIMATE ISSUES IN FINNISH UPPER SECONDARY SCHOOL PHYSICS

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Keywords: Project-based learning, engagement, climate education.

INTRODUCTION

Climate change, alongside biodiversity loss, global pandemics, and shortages of fresh water and food, is a major global challenge with no simple solutions (Incropera, 2015). Climate change is a key topic in policy discourse (United Nations, 2015) and school curricula (FINEDU, 2019). However, implementing climate education to teaching practices is challenging. Deng (2020) highlights the need to interpret and transform content related to climate issues in ways that cultivate students' capabilities, such as acquiring new climate-related knowledge and designing solutions for mitigating climate change (Deng, 2020, p. 32).

Climate education is challenging due to its interdisciplinary nature (Hinesjeffrey et al., 2013). While the basics of global warming are simple, mitigating climate change requires understanding it as a multidisciplinary issue, involving natural sciences, social sciences, engineering, economics, and education. This mitigation demands a range of competencies, including creative and critical thinking, positive attitudes, sustainable values, and socio-emotional skills, to build a sustainable future and understand climate change and its mitigation (Hestness, 2015). A key challenge is that climate change education often aims to influence students' behavior.

There are no single pedagogical solutions for engaging students in learning about climate change and its mitigation (Favier et al., 2021; Hestness et al., 2015). Review papers suggest that climate education should emphasize participatory, interdisciplinary, creative, and affect-driven approaches that are personally relevant and meaningful to students (Rousell et al., 2020; Stratton et al., 2015). Monroe et al. (2017) advocate for project-based learning (PBL), while Jorgenson et al. (2019) recommend designing and adopting innovations that save energy and raw materials.

Student engagement in learning involves the relationship between the student and elements of the learning environment, such as teachers, peers, instruction, activities, materials, and curriculum (The US National Academies of Sciences, 2018). We approach situational engagement through flow theory (Csikszentmihalyi, 2014), focusing on interest, skill, and challenge. For engagement, students need situational interest, task challenge, and the competence to undertake the task. This definition emphasizes the emotional and cognitive components of engagement (Marks, 2000).

Project-Based Learning (PBL) mirrors working life projects, with aims, stages, and concrete outcomes like reports, videos, or presentations. PBL is flexible and defined by its characteristics. It starts with a driving question that contextualizes learning and highlights core ideas and practices. These practices include defining problems, planning investigations, analyzing data, building models, and evaluating solutions (Miller et al., 2018). PBL involves active student participation and collaboration, working with concrete artefacts such as research questions or models. Central to PBL is scaffolding to support students' learning in the proximal zone (Krajcik & Shin, 2014).

The aim of this proposal is to introduce how project-based learning (PBL) engage upper secondary physics students in climate related learning. For this purpose, a climate education teaching module was designed in collaboration with teachers.

METHODS

Researchers and four physics teachers in Helsinki metropolitan area designed and implemented a climate education module. This collaboration combined teachers' and researchers' expertise in a long-term research-practice partnership (Coburn & Penuel, 2016). The module, implemented in nine classes of one school, used Project-Based Learning (PBL) to engage students (Inkinen, 2020; Jorgenson, 2019; Monroe et al., 2017). It focused on "producing and using energy and materials" and "the mitigation of climate change." The driving question was, "What actions can I and we take to mitigate global warming and contribute to a carbon-neutral society?" Topics included scientific, social, ethical, and political views on climate change (Rousell et al., 2020).

The data was collected during a school year 2023-2024 as a part of Climademy and ClimComp projects. In average 221 students participated in the course and answered in the data-collection situations. The module consisted of five 90-minute lessons. Students downloaded the m-Path app (Mestdagh et al., 2023) on their own mobile devices at the beginning of the course, which was used to collect momentary data through a short experience sample method (ESM) questionnaire and each student had 15 opportunities to answer the questionnaire, resulting in 2253 completed ESM questionnaires from 135 measurement situations. Momentary data collection was intensive and interrupts the lesson several times, so the questionnaire was short, and it took about one to two minutes to answer the questionnaire (Hektner et al., 2007).

The situational engagement was measured with Likert-scale items relating to situational interest, skills, and challenges (Csikszentmihalyi, 2014) using questions such as "Is the activity interesting?" (1 = not at all to 4 = very much); "Your skills in the activity" (1 = low to 4 = high); and "Challenge of the activity" (1 = low to 4 = high). In the context of this ESM measurement, we operationalized engagement as a state of involvement in a learning task identified by higher-than-average individual states of interest, skill, and challenge (Reschly & Christenson, 2012). Second, we asked students to select the practice they were conducting in the situation from a list of practices that we provided, such as working with data, working on a problem and design a solution. Until now we have conducted preliminary analyses, which included descriptive statistics.

RESULTS

The engagement measure was created as a dummy variable. A student response was considered engaged (= 1) when a student simultaneously reported high levels (Likert scale of 3 or 4) of challenge, skill, and interest. If one or more of these emotions was below 3, then the response was counted as not engaged (= 0). Next, percentages of engagement were calculated and presented by practices in Figure 1.

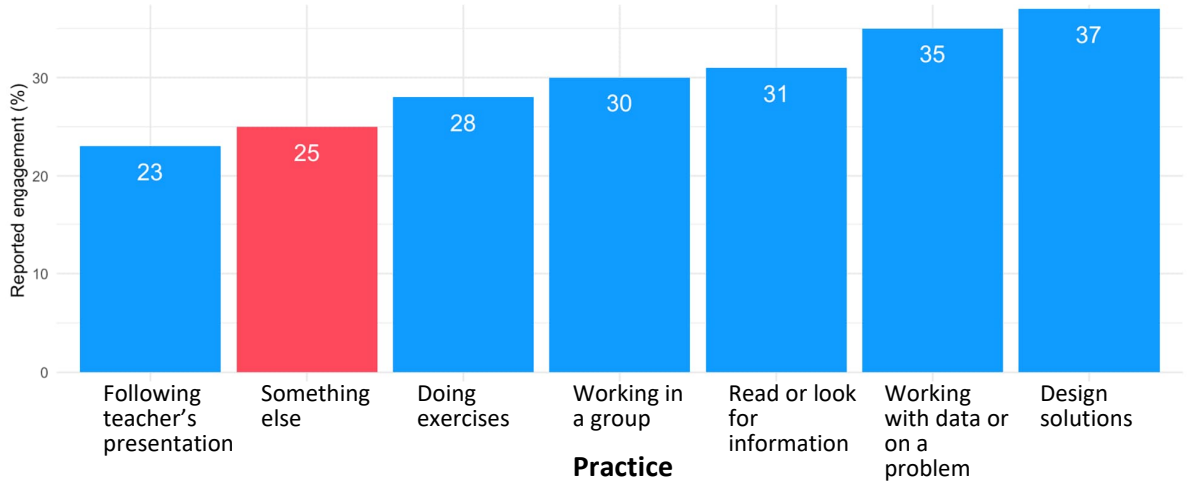

Figure 1. Percentages of situations, student reported engaged in different practices.

CONCLUSIONS

The most engaing situations were, when students were working with data, working on a problem and design solutions. This is actually, what we were expecting based on the previous studies. Monroe et al. (2017) and Jorgenson et al. (2019) suggested that students should be guided in climate related project-based learning (PBL) or design solutions that save energy in order to support their engagement and learning. It will be important that the climate education PBL teaching unit will especially guide students to work with data and problems and design solutions for mitigating climate change.

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THE SUSTAINABILITY ROAD MAP OF LEMPÄÄLÄ HIGH SCHOOL

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Keywords: climate change education, activism, young people

INTRODUCTION

In Lempäälä high school, sustainability has not been so much about a single act, but in general about the means by which sustainability and community spirit can be combined in the school community and create the basis for a new kind of school culture. In this abstract, the case study of Lempäälä high school is presented, introducing the Climate Warriors project.

Starting point

Lempäälä high school is the so-called general upper secondary school, with a total of approximately 440 students and the entrance limits have been at the 7.4 – 7.8 level. The strength of the school is that people know each other and are proud of the strong community. In a rather small but vibrant municipality like Lempäälä, working together is written into the essence of the municipality. Things do not happen without cooperation, for example matters concerning sustainable development cannot be left to the responsibility of office holders. That's why our high school has long cooperated closely with the municipality and other actors, such as the entrepreneur association, sports clubs and other actors.

In the fall of 2018, many students expressed their concerns about the state of the environment and how our planet will endure as the population grows and the environmental crisis and nature loss progress. The students felt that environmental themes are ignored in many subjects and that their position is quite minor. Climate change is a topic among others, excluding the subjects of geography and biology, which started to seem strange to all of us considering the importance of the phenomenon. The young people said that, therefore, there is no discussion in the lessons about what kind of actions we should take as individuals, let alone as a collective, to solve those worrisome issues.

So, in September 2018, a few of us teachers sent a message to the school's students and teachers inviting everyone to a joint event. Three or four teachers and a total of 23 students came and together we decided to start doing concrete things for the environment together. Teachers made it clear, that students were at the center of the activities and the teachers´ role would mainly be just to coordinate the activities.

Warrior action begins

There was a very good and active spirit in the group from the beginning and the young people enthusiastically set out to plan the goals of the activity, the visual look, etc. The name Ilmastosoturit (Climate Warriors) received the most support from the suggestions. The transmission of information from young people to young people was felt to be important, as well as the fact that we strive to inspire people to take concrete actions. Spreading hope also became the central goal of the Climate Warriors' activities.

The warriors organized various activities and events on the home campus and in other schools and public spaces, such as the library and the Ideapark shopping center. They made statements to decision makers, created connections with various expert organizations and were developing teaching materials. They received invitations to panels, such as the Ministry of the Environment's round table discussions and organized various discussion events themselves.

Attention was initially focused on the campus's own affairs. At their suggestion, the vegetarian food option was moved to the first place in the lunch line, and the consumption of vegetarian food increased by thirty percent. The skilled and flexible staff of ISS Kitchen on campus began to offer a spectacular vegetarian option every day. The problem of food waste for almost 800 people was solved exceptionally well when

the Warriors created a WhatsApp group with the kitchen, which helped to organize the sale of the leftover food. In addition to this, the Warriors have collected trash, organized flea markets and so on.

The culture of the school is changing

Climate warrior activities have strongly shaped the school since Autumn 2018. Older generations and teachers have recruited new age groups to join the activity. There are currently about 120 warriors in total, which means that about a quarter of each age group is involved in the activity. Some of the Warriors are on "rest shift" when the energy is low or when studies or other obligations take time and resources. Since 2018, the most active weekly group has had an average of around 50-60 students.

About a third of the teachers, are involved in Warrior activities. There is also a school development group among the staff, which includes five Warrior Teachers. A small special compensation is offered to these teachers for directing the operation. Responsibilities are shared among the group and development about the future, especially the ways on how to implement the Climate warrior goals and projects to practices in different school subjects.

The main reason behind the large number of Warriors is that students are already familiar with Warrior activities when they enter our high school. A large part is recruited to join a certain project and task. Since the beginning of the academic year, several different projects are offered, in which different young people are "employed". The largest employer is the school visiting group; there are altogether about forty young people involved. School visits are usually made by first grade students, but older students take part or at least plan the visits with them. During the school year, the Warriors make about 30 visits to schools of different grades. In addition to that, they receive about twenty invitations to other various events.

When organizing events, concrete and effective cooperation with partners is done. A broad network has been established, including universities, associations, organizations and companies. The cooperation with various operators in Lempäälä municipality since the beginning has proven to be particularly important. Lempäälä is a member of HINKU -municipality network (program were municipalities try to become carbon neutral). The Warriors may have been bringing these goals to the notice of the municipal residents in different ways and inventing ways to achieve the goals with various actors.

Over the past few years, methods that allow environmental themes to fit better into the school's normal everyday life were developed. The development is also accelerated by the fact that almost every group includes Warriors who are close to these themes. For example, the compulsory first-year courses of geography and history were combined into a "climate change and population development course", where the subjects have their own themes, but phenomena such as population development are examined simultaneously from the perspectives of geography and history. Those participating in the course also take only one final exam.

Along the way, several surveys for Soldiers were conducted and according to them, young people feel that Soldier activities develop various useful skills and, what is gratifying, reduce environmental concerns. The young people also feel that it feels nice and meaningful to be a member of the Warrior Community and to contribute their gifts to the common good.

Teachers have also gained enormous new enthusiasm, know-how and work perspective from the activity. For some, the work identity has completely changed with the Warrior operations. The Climate Warriors are involved in many different university projects, in which we are sometimes involved as "customers" and sometimes as "sellers". One of the current projects is the CLIMADEMY -project of the University of Helsinki.

RESULTS AND CONCLUSION

The Lempäälä Upper Secondary School has implemented the goals of the EU's GreenComp competence framework, following a strategy that starts with the approach of competence area 4.4 Acting for sustainability. The decision for such approach was based on school visits and surveys showing that on average young people are not particularly concerned about climate and environmental issues. The worry and anxiety are focused on the whole future and, above all, on the question of “where I will find my place?” Although it is difficult to get young people motivated about environmental protection, it is easier to get them excited about working together. When young people are brought into cooperation with various expert

bodies to implement a project, the bath effect known from language teaching takes place: young people learn the language of sustainability, values and attitudes. At the same time, they learn knowledge and skills and get confirmation of their own strengths. There is no harm in the fact that projects often have a variety of more general effects. The educational institution becomes a living organization that benefits its environment in many ways. And young people get the idea that they can really influence the world around them.

CLIMADEMY PEDAGOGICAL MODEL

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Keywords: Pedagogical model, Competence framework.

INTRODUCTION

In this contribution, we introduce the pedagogical model developed in CLIMADEMY. A key outcome of the project is a comprehensive training framework for both in-service and pre-service teachers, designed to enhance their understanding of climate change drivers, impacts, and mitigation and adaptation strategies—ultimately strengthening their teaching and learning approaches to climate education. The pedagogical model was crafted to integrate policy directives, accommodate school constraints, address teachers' needs, and work toward building a new school ecosystem by establishing inter- and transdisciplinary boundary zones. Specifically, the model was built to address the following questions: *What type of materials and educational support do secondary school teachers need to incorporate climate change in their teaching? What challenges does climate change education pose to science teachers and the school ecosystem? What type of institutional, disciplinary, epistemological, and relational transformations are needed to include climate change in school curriculum and, hence, in teacher education?*

METHODS

In order to design the pedagogical model, we started with a qualitative survey aimed at mapping teachers' needs. The survey was based on focus groups with 41 teachers and student-teachers involved in the four hubs of our project. The focus-group discussions were transcribed and analysed using a bottom-up thematic analysis, which led us to identify four main clusters of needs:

Disciplinary – The need to enrich and improve subject-matter knowledge, and to redefine teachers' sense of expertise.
Educational-practical – The need for concrete but flexible, open-ended resources.
Orienteering – The need for goals and shared values that guide teachers' instructional choices.
Institutional – The need for a supportive and socially responsive school system.

To respond to teachers' needs, we searched, in Science Education Research, for theoretical frameworks, examples of resources and practices, that could be used in the teacher education contexts to support teachers along five dimensions (see Fig.1):

- analyse, shape, and re-generate content knowledge (*epistemic-cognitive dimension*);
- experience inclusive and engaging learning environments and psychologically safe forms of participation (*pedagogical dimension*);
- co-design, co-learn and co-teach in interdisciplinary boundary zones (*relational dimension*);
- question institutional barriers among disciplines (*institutional dimension*);

- share social, political, and epistemic values and goals (*socio-cultural dimension*).

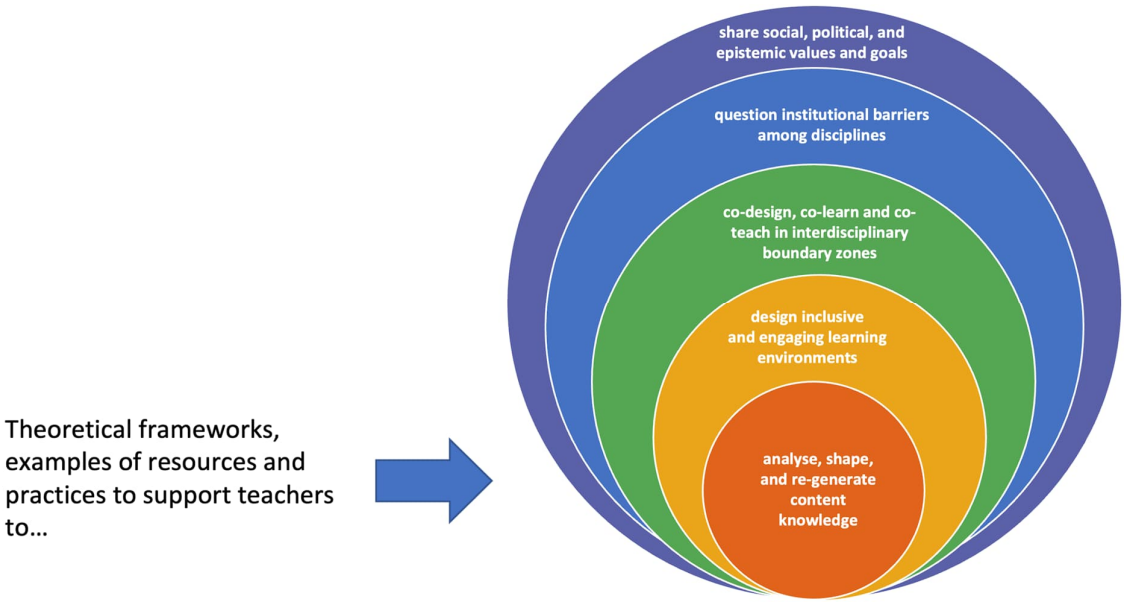

Figure 1 – Multi-dimensional structure of CLIMADEMY pedagogical model

RESULTS

Within the epistemic-cognitive dimension, CLIMADEMY draws on the Model of Educational Reconstruction (MER), as well as the Educational Reconstruction for Teacher Education (ERTE) and a modified Content Representation (CoRe) tool, to support teachers in elementarizing complex climate science knowledge (Duit et al., 2012) while fostering critical thinking and agency. By integrating Pedagogical Content Knowledge (PCK) with expert insights, teachers transform climate content into meaningful forms for students without sacrificing depth (Loughran et al. 2008). In the pedagogical dimension, participant frameworks and the MERID model (Michailidi & Stavrou, 2021) prompt reflection on roles, accountability, and the flow of knowledge, while Barquero and colleagues Study and Research Paths for Teacher Education (SRPs-TE), inspired by the Anthropological Theory of the Didactic (ATD), guide co-learning, co-designing, and co-teaching phases (Barquero et al., 2028). The relational and institutional dimensions build on Akkerman and Bakker's boundary framework (2011), enabling teachers to co-inhabit interdisciplinary zones where they negotiate meanings, hybridize practices, and work through communication barriers. Finally, the socio-cultural dimension is framed by a CLIMADEMY competence framework that expands GreenComp (Bianchi et al., 2022) with climate-specific knowledge.

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OBSERVING, TELLING STORIES, TAKING CARE. TEACHER TRAINING AND CLASSROOM PATHWAYS AFTER CLIMADEMY

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Keywords: GreenComp Framework, storytelling, outdoor education, data humanism

INTRODUCTION

This contribution reports on the work carried out over the past months after the teacher training I attended in Bologna (summer 2024) and in Hyytiälä (September 2024). I developed a series of learning pathways that, in both approach and method, were inspired by the enriching educational experiences I shared with researchers and colleagues at Climademy.

The Summer School in Bologna was essential for gaining an in-depth understanding of the GreenComp Framework and comprehending the importance of values and future vision in sustainability education. Similarly, I was able to deepen my understanding of a humanistic approach to data and familiarize myself with a variety of interactive tools such as Datawrapper, EOBrowser, Climate Visual, Climate Data, and the En-ROADS Simulator.

In Hyytiälä, I had the opportunity to explore in greater depth the potential of an interdisciplinary approach to sustainability issues, while also enhancing my humanistic perspective. I realized that the narratives related to our world, its changes, and possible future scenarios are still to be written, and that the contribution of schools and the awareness of students are crucial. In particular, I remember the experience of the Climate Warriors and their teacher's motto: *give them fun and let them shine!*
All of this led to reflections that resulted in two types of actions: Teacher training and Classroom pathways.

TEACHER TRAINING

Before the start of the school year, I held a ten-hour course for 12 colleagues from different fields of study. I shared with them the principles of GreenComp, the humanistic approach to working with data, and some open access interactive tools. The course was active and experimental, and some of the activities tested in Bologna and Hyytiälä were shared. The dissemination prompted some colleagues to reconsider the "traditional" perspectives they had followed until then and incorporate sustainability and climate-related pathways into their curricula.

Starting from March 2025 I also held, in collaboration with Fondazione Golinelli, ten-hour courses for other schools, aimed at creating maps and narratives based on data, in order to strengthen students' data literacy and raise awareness on environmental issues.

CLASSROOM ACTIVITIES

The activities involved 48 students (11-12 years old) and followed two lines of focus and development.

Methodology and Preparatory Activities (not directly addressing environmental issues). We began working with data - small and big data - through various activities, all centered on interdisciplinarity and blending perspectives (art, language, maths, literature). The students are learning to tell stories - and to

tell their own stories - through data, which represents the essential starting point for a future literacy that will also develop through interactive tools dedicated to possible scenarios.

Environmental and Climate Insights: We launched an outdoor education program aimed at encouraging students to observe, live in the present, and pay attention to the characteristics of the environment around them. This practice helps them connect with it and develop daily awareness of the human-environment interaction and the ongoing changes.

In parallel, I created a section in the classroom library dedicated to picture books, novels, short stories, poems and popular science texts that can expand students' knowledge of stories, values, and visions related to the environment and sustainability and climate change.

PRELIMINARY CONCLUSIONS

For the next two years, it is planned to continue along the established path through:

- An update of teacher training, with the sharing of best practices and a discussion on the results achieved in terms of the effectiveness of the proposed activities and student awareness.
- A progressive deepening of the topics related to climate and sustainability, as well as an increasing extension of the concept of complexity in accordance with the age and development of the students.

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CLIMATE CRISIS AND MEDIA LITERACY

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Keywords: Media literacy, Misinformation, Climate crisis.

ABSTRACT

Media literacy is a cornerstone for navigating the intricate and often polarized discourse surrounding climate change. In this presentation, we delve into how educators can empower students to critically evaluate information, distinguish credible sources, and address challenges such as misinformation, denialism, and political biases that often obscure climate science. Teachers are uniquely positioned to guide students in understanding the complexities of climate-related issues and their societal implications.

This session encapsulates insights from a course delivered as part of Climademy 2024 program for Italian teachers and highlights several years of work with Fondazione Golinelli on this topic. These efforts focus on equipping educators with tools to foster critical thinking, enabling students to engage responsibly with the media and climate debates.

By building students' capacity for critical analysis and fostering awareness of climate change's urgency, educators can prepare them for informed civic participation. This session shares lessons learned, good practices, and challenges encountered, aiming to inspire and support teachers in cultivating these essential skills.

EXPLORING THE POTENTIAL OF DATA-DRIVEN EDUCATIONAL TOOLS TO ENGAGE STUDENTS WITH CLIMATE CHANGE COMPLEXITY

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Keywords: Climate change education, Complexity, Scenario-making.

INTRODUCTION

Climate Change Education (CCE) is essential for driving a shift toward a sustainable and decarbonised society. Environmental observatories and science labs are central to delivering impactful educational experiences by integrating real-world data from monitoring stations and satellite observations. These tools foster scientific inquiry and empower critical thinking about climate change and its effects.

CCE inherently requires integrating socio-economic, political, environmental, and technological knowledge (Kumar et al., 2023; Stevenson et al., 2017), aligning with Funtowicz and Ravetz's (1993) concept of post-normal science, where traditional disciplinary boundaries are insufficient to address problems characterised by uncertainty and high stakes. As noted by Moltan-Hill and colleagues (2019), higher education institutions must embed CCE within broader sustainability efforts, adopting systemic strategies to prepare informed citizens and policymakers. To this extent, reflexive, inquiry-based, and creative learning methods are identified as crucial for equipping students with critical thinking skills. Stevenson and colleagues (2017) and Finnegan (2022) emphasise that these methods can inspire hope and promote a sense of agency, empowering learners to envision and work toward sustainable futures (Ojala, 2015).

Overall, the literature underscores the need for CCE to transcend traditional educational structures, addressing its complexity and controversial nature through interdisciplinary, reflexive, and participatory approaches. By equipping both educators and students with the necessary knowledge and skills, education can play a pivotal role in addressing the urgent challenges posed by climate change.

METHODS

This contribution introduces F*you*TURES, an innovative scenario-making game designed to achieve these objectives by combining real-world data, collaborative learning, and scenario-building exercises (De Zuani et al., 2024). At the heart of the game lies the En-ROADS simulator (Energy-Rapid Overview and Decision Support), a global climate simulator developed by Climate Interactive in partnership with the MIT Sloan Sustainability Initiative and Ventana Systems (Rooney-Varga et al., 2021). En-ROADS offers an interactive platform for exploring how climate policies influence long-term outcomes. It is built on exogenous variables chosen by the user, like technology breakthroughs, base GDP growth or policy choices, and endogenous variables set by the developers, like energy specifics, climate impacts and other technical info. These values are determined by integrating external datasets for initial conditions and parameters and comparing them with historical and projected data from other climate models (Chikofksy et al., 2024). This system dynamics model is designed to provide real-time feedback to users through an intuitive web interface available in multiple languages. The simulator employs differential equations to depict the climate-energy system as a dynamic entity characterised by feedback loops, nonlinearities, and time delays. Users can simulate the effects of policies like electrification, carbon pricing, and improved agricultural practices on variables such as energy prices, global temperatures, and sea-level rise.

Using the En-ROADS simulator, FyouTURES guides players through three rounds spanning the present day to 2100, with milestones in 2030 and 2050. The game adapts the simulator's categories into six

thematic areas: conventional sources of energy, emission control, green areas, energy efficiency, electrification, and green energies. These themes allow participants to explore diverse aspects of sustainability, including renewable energy adoption, deforestation, and CO2 removal technologies.

To enhance decision-making and incorporate uncertainties, we introduced 15 wildcards representing possible events tied to climate and societal factors. These cards reflect different types of uncertainties related to Climate Change – epistemic, aleatoric, and reflexive (Shepherd, 2019) – and challenge players to adapt strategies dynamically, encouraging critical engagement with complex climate issues.

The game has been implemented twice, with an overall number of 60 12th and 13th grade students from schools near the University of Bologna. Here, we present the analysis of the data collected during the first implementation. The analysis is qualitative and based on data collected both during and after the course, such as activity recordings, questionnaires, and semi-structured interviews.

RESULTS

The implementations demonstrated how the game helped students deal with complex sustainability challenges in an attempt to create scenarios that balanced environmental, social, and economic sustainability dimensions (Purvis et al., 2019). The game's structure promoted collaborative problem framing over simplistic solutions, fostering open-ended reasoning and a deeper understanding of "wicked problems." Two main results can be pointed out in students' approaches to the game.

The first one is a general tendency to embrace a reductionist and "solutionist" approach. Students' effort was mainly devoted to optimising the strategy in search of a quick solution to the task. This optimisation often involved isolating the different dimensions of the problem, disregarding the choices' effects, and favouring cause-oriented strategies that prioritised problems' mitigation while undermining socio-economic implications. As a result, many students ultimately created dystopian scenarios where temperature goals were quickly met at the expense of severe socio-economic inequalities. This outcome highlighted the risks of focusing solely on macro variables, such as temperature and sea level rise, and reducing sustainability to an environmental issue.

The second aspect is connected to students' approaches to the En-ROADS simulator. During gameplay, students initially approached the simulator as a straightforward tool, focusing primarily on reaching environmental goals without integrating social or economic factors. This approach reflected a persistent classical mindset: the tendency to see problems as technical or quantitative challenges rather than complex socio-environmental issues intertwined with ethical implications. Their inclination to view the simulator as a neutral instrument highlighted a common detachment between facts and values, whose connection is instead emphasised by post-normal science (Funtowicz & Ravetz, 1993) as necessary to address complex, value-laden problems. At the same time, as observed during the implementation of the game, we noticed that the game's inherent complexity was sufficient to accommodate reasoning patterns essential for addressing multifaceted challenges, and the structure of the game enabled students to think together and engage with climate change as a complex phenomenon. The final outcome of their scenarios showed how the construction of a desirable scenario was not a matter of reductionism but required grappling with interrelated values and issues, reflecting the non-separability of the three sustainability pillars (Purvis et al., 2019).

CONCLUSIONS

The course and the game provided participants with an opportunity to explore the complexity and intricacy of sustainability and climate change decision-making, highlighting the interconnectedness of social, political, ethical, economic, natural, and technological factors.

By integrating the scientific rigour of En-ROADS, interactive simulations, and collaborative learning dynamics, FyouTURES highlights the potential of data-driven educational tools to engage students with

the complexity of climate change. This approach equips learners with critical thinking skills while challenging them to navigate uncertainty and envision pathways to sustainable futures.

The game experience encouraged students to confront the limitations of classical views on problem-solving, illustrating how complex issues like climate change demand more than simplistic or monodimensional approaches.

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BRIDGING CLIMATE STRATEGIES – THE CLIMATE FITNESS CHALLENGE AS A TOOL FOR COLLABORATION AND EDUCATION

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Keywords: Climate Fitness, Holistic Climate Strategies, Serious Game, Transmedia

INTRODUCTION

Climate change is one of the biggest global problems of the modern world (Calvin et al. 2023), which requires not only environmental resilience but also social equity, technological integration, and long-term resilience (Lin et al. 2021). However, many of the current strategies fail to adopt a holistic perspective, instead analysing climate challenges from a limited viewpoint that often focuses on one or two dimensions, such as ecology or technology, while neglecting the interconnected social, economic, and historical power dynamics that shape urban environments (Dong et al. 2024; Silva, Silva, and Carvalho 2022; Suhardono et al. 2024). In order to fill these gaps, the Urban Climate Reactor (UCR) research team proposes the "Climate Fitness Framework", a multidimensional framework for assessing urban climate strategies according to four dimensions: coping capacity, adaptability, transformability, and eco-harmony.

The term "climate fitness" is not a common term in English literature, thus presenting a chance to propose a new conceptual framework that integrates ecological, social, and technological aspects in urban contexts. Although widely used in German-speaking research fields, including construction, spatial planning, and industry, the term is usually used restrictively or jargon without clear contextual definitions (Michel and Helnwein 2023). The UCR framework extends this concept in an attempt to achieve the following three main goals: (1) Biodiversity and human well-being; (2) Justice and equity; and (3) Sustainable and climate-proof cities through integrative planning and innovative technological solutions, building upon the foundational works of Ferreira et al. (2022), Palabıyık (2021), and Zhang et al. (2024).

In order to make the findings accessible to a wider audience, the UCR team created the "Climate Fitness Challenge". This serious game, developed using principles of gamification and transmedia storytelling (Tombleson 2024; Smiderle et al. 2020), translates complex research findings into an engaging, interactive experience. By situating participants within realistic urban planning scenarios, the game fosters critical thinking and collaboration, emphasising the interconnected roles of social equity, ecosystem services, and technological solutions.

METHODS

The "Climate Fitness Framework" was developed in a systematic way in a multi-stage process. First, an explorative literature review was conducted to identify different approaches and gaps in the climate fitness definition. In the second stage, case studies were conducted to adapt and validate the framework. First, the use of PV tiles was investigated as a new technology, and the results highlighted challenges with feasibility, durability and acceptance (Li, Ma, and Wang 2023). The second case study was based on New York's High Line Park, one of the world's most famous green infrastructure projects. Although the High Line Park was successful in ecological and recreational aspects, the analysis revealed issues of gentrification and unequal access, highlighting the need for urban greening projects to be accompanied by social policies that protect and support the local community (Huebner 2019).

Based on the findings of the "Climate Fitness Framework" (Michel and Helnwein 2023) the serious game "Climate Fitness Challenge" was created. The focus of the game was on the climate-fit design of the Westbahnpark, taking into account the developed definition of "Climate Fitness". The Westbahnpark

initiative (WESTBAHNPARK.JETZT, n.d.) in Vienna served as a key source of inspiration for this project. While still in the proposal stage and not yet under development, the Westbahnpark reimagines urban parks as drivers of social-ecological change. The initiative envisions transforming a linear, underutilised urban space along Vienna's railway infrastructure into a dynamic public park that prioritises ecological restoration, accessibility, and climate resilience. This proposed project highlights how parks can simultaneously address environmental degradation and urban inequalities, emphasizing the potential of urban green spaces to act as catalysts for sustainable urban development.

RESULTS

The "Climate Fitness Challenge" is represented as a role-based board game that allows players to participate in cooperative urban planning. Players assume the role of stakeholders, for instance, policymakers, environmentalists, or community representatives who have different agendas and goals to develop a climate-fit urban park within a specific budget. Realistic scenarios are used for decision-making, which includes issues in climate change adaptation and mitigation, such as reducing the effects of the urban heat island, increasing the availability of parks, or enhancing biodiversity and stormwater management, among others. Through critical discussions, players learn about the issues of equity in design, ecosystem services, and technology integration. The game is designed in a manner that encourages participants to reflect on different points of view in decision-making, finding middle ground as a team, and consider the long-term consequences of such decisions. This immersive game experience is further intensified by real-world challenges such as budget constraints and political shifts protests, compelling participants to adapt and refine their strategy. The climate fitness score, a comprehensive indicator, reflects the park's impact on ecological sustainability, social cohesion, public health, economic viability, and technological progress. Set against the backdrop of actual urban settings in Vienna, the game presents realistic scenarios, offering an experiential learning opportunity.

CONCLUSIONS

The proposed workshop session presents an interactive tool for climate change education, aligning with the CLIMADEMY Conference goals of empowering learners, encouraging systems thinking, and inspiring climate action. The "Climate Fitness Challenge" exemplifies how participatory and evidence-informed approaches can improve climate literacy in formal and non-formal education. Expected outcomes and participant learnings of the session include:

- Developing a deeper understanding of climate adaptation and mitigation strategies in urban contexts.
- Recognising the role of parks as key drivers of resilience and providers of essential ecosystem services.
- Enhancing critical thinking, systems thinking, and collaborative decision-making skills.
- Gaining hands-on experience with gamified tools for fostering education and community engagement.

We propose a workshop session that begins with a brief introduction to the project and the concept of climate fitness, highlighting its multidimensional approach to urban adaptation and mitigation strategies. The majority of the 90-minute session will be dedicated to hands-on gameplay in groups of five participants per game board, where each group will collaboratively discuss and debate differing adaptation and mitigation measures for the park they are tasked with designing. The workshop will also serve as an opportunity for the research team to observe group dynamics during the game, gathering data and insights into how players negotiate trade-offs, build consensus, and reflect on the concept of climate fitness. A recap at the end will allow participants to engage in a broader discussion, sharing their learning experiences, offering feedback on the game, and identifying potential areas for improvement. For the workshop, only a projector, chairs, and tables will be needed to facilitate the introductory presentation and gameplay.

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DEVELOPMENT OF SUSTAINABILITY COMPETENCES FOR ANALYSING AND NARRATING REAL-WORLD CLIMATE DATA: THE SALOMON PROJECT

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Keywords: Co-teaching, Co-Design, Interdisciplinarity, Complex thinking.

THEORETICAL BACKGROUND

Addressing climate change requires equipping the younger generation with the knowledge, skills, and attitudes necessary to envision and contribute to a sustainable, carbon-free society. Recognizing this urgency, the European Union's GreenComp framework underscores the importance of fostering sustainability competencies (Guia *et al.*, 2022; Ben *et al.*, 2019). In response, the Salomon Project was conceived within the Italian HUB of CLIMADEMY as an innovative educational initiative that integrates complexity science, interdisciplinary co-design and teaching, and real-world climate data to cultivate systemic thinking and sustainable practices.

CONTEXT AND OBJECTIVES

The Salomon Project is an initiative led by the Liceo 'A. Einstein' scientific high school in Rimini in collaboration with the University of Bologna's physics education research group. Engaging five classes (four grade-12 and one grade-11), the project aims to develop GreenComp's twelve sustainability competencies, enabling students to tackle global challenges like climate change through innovative interdisciplinary approaches that cultivate problem-framing, analytical, and systemic thinking.
The project bridges scientific and humanistic disciplines through collaborative co-designing and co-teaching, creating a shared framework of interdisciplinary activities. These activities introduce students to the scientific paradigm of complexity, equipping them with tools to critically reflect on and address the challenges posed by climate change. Integrated into the curricular timetable from January to May 2025, these initiatives have the ambition to provide not only knowledge and skills but also all attitudes to consciously reflect and work on real-world climate data.
Aligned with GreenComp's areas of competence, the educational objectives of the Salomon Project emphasizes:

- Embodying sustainability values': Students explore the complex spatial and temporal balances underlying life, promoting harmony with nature and civic responsibility.
- Reflecting on identity: Activities encourage students to examine their role as individuals and members of interconnected and generationally diverse societies.
- Embracing complexity: Through systems thinking, problem framing, and critical analysis, students learn to value processes and question underlying assumptions.
- Envisioning sustainable futures: Creative exercises inspire the imagination of possible, probable, and desirable futures through interdisciplinary perspectives.
- Acting for sustainability: Hands-on activities nurture civic awareness and informed decision-making for sustainable living.

To achieve these objectives, on the scientific front, the project challenges students to reconsider classical physics paradigms, such as Newtonian mechanics and thermodynamics near equilibrium, introducing a vision of science that embraces complexity. Specifically, it aims to:

- Investigate key concepts like multiplicity, irreducibility, and circular causality.
- Promote a nuanced understanding of uncertainty and non-linearity in complex systems.
- Engage critically with real-world environmental issues.

This innovative approach emphasizes interconnectedness and complexity, encouraging critical thinking competencies that empower students to confront climate challenges with confidence, responsibility, and agency toward sustainability.

DESIGN AND METHODOLOGY

The project begins with a collaborative co-design phase (October-December 2024), bringing together teachers of humanities (literature, philosophy, history, arts) with teachers of science disciplines (physics, mathematics, natural sciences). By fostering interdisciplinary dialogue, the initiative transcends traditional disciplinary boundaries to develop creative solutions to sustainability challenges.

Central to the project is introducing students to complexity science concepts like non-linearity, circular causality, emergence, and unpredictability. Inspired by Italo Calvino's *Invisible Cities*, the project employs metaphors and allegories to examine sustainability concepts. Calvino's cities, imagined as spaces of possibility, ambiguity, and relational complexity, provide a framework for addressing systemic interdependencies. This approach encourages students to explore the "boundary zones" between disciplines, fostering creativity and deeper understanding.

Throughout the project, students engage with multiple expressive languages—textual, photographic, theatrical—and participate in practical physics lab activities. This integration reinforces theoretical knowledge through experiential learning, equipping students with the skills and attitudes to apply their understanding in real-world contexts.

Real-world climate data serve as a cornerstone, linking abstract scientific concepts to tangible environmental phenomena. Starting in April 2025, students will analyze data from sources like the Finokalia monitoring station (University of Crete), the European Extreme Events Climate Index (E3CI), and the En-ROADS climate simulator. The project culminates in June 2025 with a workshop focused on analyzing, interpreting, and narrating climate data. This final phase emphasizes the complex interconnection between the scientific, cultural, economic, and social dimensions involved in climate change, promoting a holistic understanding.

CONCLUSIONS

The Salomon Project exemplifies the transformative potential of climate change education through interdisciplinary collaboration between humanities and science disciplines, complexity science, and real-world climate data. By fostering systemic thinking, responsible action, and imagining desirable futures in harmony with sustainability values' it aligns with the GreenComp framework and CLIMADEMY's broader mission. Ultimately, this initiative enhances climate literacy, empowering students to navigate and address the complex challenges of a rapidly changing world.

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ACID RAIN, IS IT PAIN? TEACHING THE PHENOMENON OF ACID RAIN IN PRIMARY EDUCATION THROUGH VIDEO EXPERIMENTS

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Keywords: Acid rain, climate change, primary education.

INTRODUCTION

The term "acid rain" is used to refer to rain that contains acidic substances resulting in a decrease in pH. It is a global environmental problem since studies have shown its effects on various materials as well as living organisms, terrestrial and aquatic. In this project, the aim was to create experiential learning conditions in a highly playful way so that young students could discover for themselves through investigation the conditions under which acid rain is created, its effects on materials and organisms, and to reflect on finding solutions, especially those that they themselves can contribute to, cultivating their environmental awareness. The above is understood by students through experiments that are easy to implement in the classroom, adapted for primary and early secondary education. Pupils build themselves an aquarium that mimics the creation of acid rain. They observe and record the effects on plants and soil using a self-sustaining terrarium they have built themselves. By providing comprehensive lesson plans that include low-cost experiments with step-by- step video-taped instructions, references to the scientific basis of each experiment, worksheets, STEM activities and online games, teachers are empowered to confidently tackle teaching global environmental issues using inquiry-based learning.

DESCRIPTION

Acid rain is used to refer to rain that contains acidic substances resulting in a lower pH than 'normal' rain. Rain is actually slightly acidic (pH 5.6) due to SO2 and NOx (from natural sources such as volcanoes), which end up as acids when they come into contact with water and oxygen. Acid rain is considered to be the result of the burning of fossil fuels and has a pH of between 4.4 and 4.2. When it falls, it can affect the ecosystem and its living organisms, as everything is interconnected.

Cultivating environmental empathy at an early age is important as this is when a child's personality and beliefs are formed. A child who recognizes and cares about environmental issues will become a responsible and environmentally aware adult. Environmental issues such as acid rain are difficult to teach in primary education, as pupils find them abstract and difficult to understand. The STEM approach can provide primary teachers with the tools to address these issues. Young learners are motivated to investigate the problem, understand its causes and effects by conducting experiments, making hypotheses and observing the results. This inquiry-based learning will promote their critical thinking skills and improve their understanding of global environmental problems.

The way of teaching at young ages is based on experiential learning, where children are encouraged to engage in 'hands on' activities and explore a topic on their own with the guidance of their teacher, as opposed to traditional teaching methods based on memorization and exercises. One teaching method that has proven to be particularly effective in early education is learning through play, which contributes to the cognitive d and the psychosocial development of pupils. Through play, students develop their sociability by forming groups, obeying rules and at the same time a pleasant pedagogical climate is created that promotes learning.

In this program, young students are introduced to a series of experiments that apply STEM to better understand the causes and effects of acid rain. Building an aquarium that mimics the production of acid rain by mixing smoke with water vapor helps young students visualize the cause of this environmental problem and raises questions about fossil fuel combustion and the solutions that can be provided. Observing what happens to the organisms living in the aquarium causes environmental empathy through understanding. The same approach applies to the self-sustaining terrarium the students built. Other simple experiments, such as planting seeds, watering them with pH 4.2 water, help visualize the results. All of this comes in the form of lesson plans, videos, tutorials, worksheets and activities that teachers can easily use to promote the scientific method and evoke environmental empathy in their students.

In the creation of the materials, emphasis was placed on the safety of the students, using non-toxic materials, the appropriateness of the experiments based on the age, cognitive level and skills of the students, and the creation of attractive activities to motivate them, such as online games to attract the interest of young students. The main objective, however, is to empower teachers in their work by providing them with the appropriate tools that have been built by teachers and tested in the classroom (from teachers for teachers), providing them with lesson plans and saving them valuable time, giving them the scientific knowledge to feel safe to approach the issue of acid rain.

The project initially contains two lesson plans, the first of which is about young students understanding how acid rain is created and what it is, while the second is about its effects on organisms and motivating students to find some solutions to this global environmental problem.

The first lesson plan includes a video experiment of how to create an aquarium mimicking the formation of acid rain and activities like turning their drawings into puzzles, discussion starter cubes, making an Ishikawa diagram of the causes of the problem and creating an acrostic poem enhancing their imagination and creativity.

The second lesson plan explores the effects of acid rain on organisms (plants and animals) and structures. It involves experiments on a) testing plant growth using water with different pH levels, b) observing acid effects on shells and eggs c) understanding ocean acidification with red cabbage juice as an indicator and d) observing the damage that acid rain can do to structures by using chalk.

It also contains activities like making an avocado pot, creating a terrarium and painting with natural indicators to understand bases and acids. Finally, children are invited to discuss (discussion starter dice game) the causes and effects of acid rain. They play online games designed to better understand and consolidate what they have learned. They create posters and leaflets to raise awareness of the acid rain problem to other pupils in the school and the local community. With the Bookcreator project they create a story based on everything they have learned which they illustrate with their own drawings enhancing their imagination and creativity.

All the material is designed in an interactive presentation format to be organised and easily accessible by teachers for immediate use in the classroom.

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As a joint project of Greece-Turkey this work has received an award in the STEM Festival of Science on Stage in August 2024 in Turku, Finland. The material is part of a wider Science on Stage project on teaching science through experiments in primary education and it will be available on the project page "Save Nature by understanding it" in early 2025.

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NATURE-BASED SOLUTIONS IN THE SCHOOL CURRICULUM

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Keywords: Nature-Based Solutions (NBS), Inquiry-based learning, Project-based learning, Urban Heat Islands.

INTRODUCTION

Education is a powerful tool for transforming the world and driving long-term action on climate change. Educational systems have a critical responsibility to raise awareness and instill sustainable and environmentally friendly behaviors. Despite the growing severity of environmental challenges, traditional school curricula have not yet fully integrated comprehensive, interdisciplinary approaches to teaching about climate change and environmental issues. EU policy initiatives, like the European Green Deal (EU, 2021) and the European Sustainability Competence Framework (Bianchi *et al.*, 2022) are providing the necessary guidelines not only for the industry and energy sectors but also the way sustainability should be introduced to education (Zotti, 2022).

In this paper, we are presenting a classroom intervention that has been designed to address these above-mentioned issues by introducing students to the global context of environmental challenges, specifically the Urban Heat Islands, and gradually localizing these challenges within their neighborhoods. By following the inquiry-based approach, using satellite data to identify environmental hotspots and exploring the effectiveness of NBS through experiments, the aim is for students to develop their critical and creative thinking, through asking questions, designing investigations, interpreting evidence, forming explanations and arguments and communicating findings. Gaining experience on how local actions can contribute to global change is an equally important aim of the present intervention.

METHODS

The intervention is integrated into the school curriculum of Ellinogermaniki Agogi and it runs for one hour per week for eight weeks. 150 students from 12 to 13 years old are participating, organized in small groups of five students.

First, students are introduced to the Urban Heat Island and the Heat Risk Index. As a means to visualize those terms, we use a digital map (Pantazis *et al.*, 2024). This map delineates areas within Athens that exhibit pronounced Urban Heat Island effects through a color-coding scheme, where locations range from green (indicating low risk) to deep red (indicating high risk), thereby localizing the global issue of climate change in their respective urban environment.

Students are then driven to investigate changes that could be made to alleviate the phenomena presented to them. Guided by inquiry-based worksheets they conduct two experimental investigations. In the first experiment (indoor), students work with various materials, including sand, a wet sponge, a dry sponge, water, wood, soil, and gravel. By subjecting them to a controlled heat source, they record the temperature changes over time and subsequently measure the cooling rates for each material once the heat source is removed. This experiment is designed to facilitate an analysis of the thermal properties of different materials. In the second experiment (outdoor), students use maps of the school premises and UV thermometers to

measure the ground temperatures of diverse surfaces, such as concrete, soil, grass, permeable surfaces, gardens, and shaded areas, within the school yard. After this practical exercise the students discern which materials and surfaces contribute most effectively to reducing ground temperatures and mitigating Urban Heat Island effects.

After discussing their conclusions on the significant difference the materials can have to ground temperatures, each team chooses a high-risk neighbourhood from the digital map to work on. This part of the map is printed for each team, with a scale bar.

Based on the research findings of "A Cost-Benefit Analysis of Nature-Based Solutions for Urban Areas" (Biasin *et al.*, 2023), a set of cards has been developed (Ellinogermaniki Agogi, NBS EduWORLD Resources). Each card presents an individual NBS, such as green roofs, permeable surfaces and urban gardens accompanied by the measured effectiveness of each solution as well as its associated implementation and maintenance costs. Each group proposes the most ideal NBS for their high-risk area. To visualise their intervention on the map, they use stickers that correspond to their chosen NBS. Following this, they calculate the area for each intervention, with respect to the scale of their maps, and using the information on the cards they calculate the implementation and the maintenance (per year) costs.

At the end of the activity, they present and discuss their ideas and findings, with professionals and local authorities. They explain their choice of NBS through reference to the experiments they conducted. The effectiveness against the Urban Heat Island effect is finally compared between the groups of each classroom, taking into account how affordable the interventions are.

RESULTS

For the last academic year, the intervention resulted in the production of 30 projects, each of them delineating areas within the city of Athens, where students proposed NBS, calculated the implementation and maintenance costs and presented at what grade each NBS contributes regarding the effectiveness against flood risk, heat island reduction and other environmental benefits. The projects were subsequently showcased at a school fair, in which more than 500 people gathered, including parents and representatives from the local authority. Through their participation in the intervention and the school fair students:

- were introduced to the environmental and climate change challenges, explored adaptation/mitigation solutions (NBS), and realized the importance and potential of nature in urban areas.
- applied the scientific method and satellite remote sensing for planning NBS.
- translated theoretical concepts into actionable, localized proposals for climate resilience, contributing to urban planning.
- presented their findings and discussed them with professionals and scientists in the related field, representatives from the local authority, and citizens.

Additionally, teachers and school heads followed a Whole-School Approach (Katikas *et al.*, 2023) by:

- applying their vision and the school's strategy for open schooling (Sotiriou *et al.*, 2021), engaging parents and the local community in the learning processes but also promoting education as part of local community development.
- following learning approaches like the inquiry-based and the project-based approach becoming facilitators in the learning process.
- reflecting on their professional practice and building their capacity for teaching through the provided training,

- using the infrastructure of the school as a field of learning,
- developing a competence-based curriculum, embracing the GreenComp and the Climademy Competence framework.

CONCLUSIONS

The findings of this study suggest that embedding interdisciplinary approaches in educational curricula can effectively bridge the gap between theory and practice, thereby equipping students with the competences and motivation necessary to address complex environmental challenges.

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CLIMADEMY COMPETENCY FRAMEWORK FOR TEACHING CLIMATE CHANGE

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Keywords: Climate Competency, Climate Change Education, Teacher Professional Development.

INTRODUCTION

Climate change education (CCE) is one of the key responses to tackling climate change (Leite, 2024; Cantell et al., 2019). To make CCE supportive for students' learning and engagement, also teachers should be supported in the planning, instruction, and assessment of CC related issues. Therefore, it is crucial to identify and specify the necessary competencies as a starting point for planning of instruction and learning and assessing of learning outcomes in the context of climate change (Brundiers et al., 2021; Wiek,

Withycombe, and Redman, 2011). By competency we mean a set of knowledge, skills, and attitudes needed for performing a certain task or needed in problem solving (Bianchi, Pisiotis, and Cabrera Giraldez, 2022; Le Deist & Winterton, 2005). In terms of climate change, a competency framework describes the functionally linked set of competencies required for understanding, mitigating, and coping with climate change (Le Deist & Winterton, 2005; Wiek, Withycombe, and Edman, 2011).

The competency framework was designed to support teachers in their climate change instruction and in an iterative process in CLIMAte change teachers' acaDEMY (CLIMADEMY), a network of four European countries (Italy, Greece, Germany, and Finland). The aim of the CLIMADEMY has been to support pre- and in-service teachers of various subjects in their continuous professional learning.

DESCRIPTION OF THE CC COMPETENCY FRAMEWORK

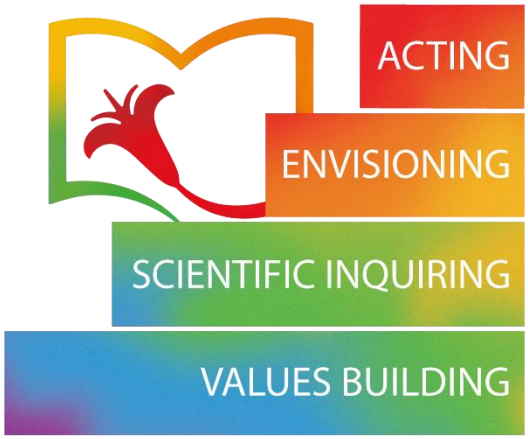
It has been noticed in educational context that broad sustainability models do not capture the needs of specific issues such as climate change (Cantell et al., 2019). Therefore, the climate change competency framework combines the previous work of sustainability frameworks with the expertise of climate change educators and researchers of CLIMADEMY. The initial structure of the framework was based on the European GreenComp framework (Bianchi et al., 2022) and supported by climate change competencies described by young Finnish people (Taurinen et al., 2024). An illustration of the CLIMADEMY competency framework is presented in Figure 1. The framework proposes comprehensive learning of climate change through four competency areas: *Values building, Scientific inquiring, Envisioning,* and *Acting*.

The core of comprehensive climate change competence is to build the foundation of values and motives. The competency of *Values building* is centred around the values and attitudes of oneself and others, and how these motivate action. The values are related to reasons of climate change, consequences, and actions. The students are encouraged to gain respect and care for the coexistence of people and natural environment, considering ethical and justice principles. In addition to the value base, the interest in the CC phenomenon itself needs to be enhanced. This is represented by the competency of Scientific inquiring. *Scientific inquiring* emphasises the understanding of the reasons behind climate change and its consequences. By fostering curiosity students are invited to explore climate change as a phenomenon, through scientific data and evidence.

Envisioning competency embraces students' creativity and ideas of the future. It revolves around envisioning life and solutions considering climate change, with the ability to explore, imagine, and generate ideas. These ideas can be about challenging the status quo, creating new solutions, or imagining future perspectives, while utilizing systems and artistic thinking. The *Acting competency* focuses on bringing plans into action. It includes critically designing, selecting, and conducting concrete actions that are aimed at

solving climate change-related problems. Collaborative skills are especially important within this competency, as the planning and doing needs to happen in an equal and democratic way.

Figure 1. The CLIMADEMY competency framework. The four competencies are called Values building, Scientific inquiring, Envisioning, and Acting.



CONCLUSIONS

CLIMADEMY proposes comprehensive learning of climate change. This could be achieved by basing climate change related instruction and assessment on the competency framework's four encompassing competencies: *Values building*, *Scientific inquiring*, *Envisioning*, and *Acting*. The framework can be used by teachers of different disciplines and grades to develop their teaching practices focused on climate change to make sure that the learning outcomes are aligned with and focused on the necessary aspects described in the climate change competency framework.

ACKNOWLEDGEMENTS

This work was supported by the ERASMUS+ project grant 101056066, Climate Change Teachers Academy (CLIMADEMY).

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REIMAGINE SCHOOLS AS EVOLVING ECOSYSTEMS: AN ITALIAN HIGH SCHOOL'S VISION AND ROADMAP

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Keywords: Sustainability, School ecosystem, GreenComp, CLIMADEMY.

INTRODUCTION

In recent years, rapid technological advancements and the climate crisis have significantly accelerated the pace of societal change, compelling educational institutions to rethink their teaching approaches. The complex demands of contemporary society require not only transmitting knowledge but also fostering the critical thinking and adaptive skills necessary for sustainability and social transformation (EU, 2015). To fulfil these goals, schools are increasingly called to integrate sustainability competencies into traditional curricula, as emphasized in the European Commission's GreenComp framework (Bianchi et al., 2022). While education has historically adapted to societal needs—such as promoting mass literacy and training leaders in 20th-century Italy—today's schools often struggle to align with modern challenges due to entrenched issues, such as outdated structures, methodologies and teacher training, coupled with a lack of collaborative frameworks. These barriers are further compounded by a culture of individualism within schools and weak connections between institutions and broader social and environmental contexts. These limitations hinder the ability of schools to fully embrace the systemic and transformative goals of the GreenComp framework.

The concept of reimagining schools as evolving ecosystems provides a powerful lens for addressing these challenges. Rooted in systems thinking and complexity theory, this perspective views education as a dynamic and interconnected system (Capra & Luisi, 2014). Schools are no longer static institutions defined by rigid hierarchies but are reimagined as cultural infrastructures capable of continuous renewal and adaptation to societal and environmental challenges. This vision aligns with the ideas of Stefano Mancuso, who emphasizes the intelligence and adaptability of plant ecosystems as a model for rethinking human systems, including education. Mancuso highlights how plant ecosystems thrive through interconnected networks of roots and symbiotic relationships, demonstrating resilience and efficiency through collaboration rather than competition (Mancuso, 2018). Similarly, schools can be reimagined as "learning forests" where the interconnected roles of students, teachers, staff and the community create an ecosystem of mutual support, resource sharing and adaptability. By fostering this culture of interconnection, schools can evolve into spaces where diversities are not just tolerated but leveraged as resources for growth and innovation.

This ecosystemic approach encourages schools to transcend traditional boundaries and actively engage with broader societal systems, much like the symbiotic networks in natural ecosystems. For example, Mancuso's concept of distributed intelligence among plants offers a metaphor for how schools can function as decentralized system, with teachers, students and leadership contributing together to decision-making and to school evolution.

As part of the CLIMADEMY Italian hub, in this contribution, we present the transformative journey of IIS Baracca-Forlì, an Italian high school that has embraced this ecosystemic vision. Supported by a long-lasting collaboration with the University of Bologna's physics education research group, our school has developed a roadmap to institutionalize effective change. This roadmap aims to reimagine schools as dynamic ecosystems, fostering systemic and transformative change in alignment with GreenComp.

METHODOLOGY AND KEY INSIGHTS

This perspective embraces ecosystem metaphors, highlighting the interdependence of agents within the school system—students, teachers, leadership and the broader community — (Sterling, 2021). It aligns with GreenComp's emphasis on fostering sustainability competencies, such as systems thinking, adaptability and collaborative problem-solving (Bianchi et al., 2022). Figure 1 illustrates how this vision of school as evolving ecosystem was implemented at IIS Baracca-Forlì (graphics inspired by *https://www.openschools.eu/open-school-model/*).

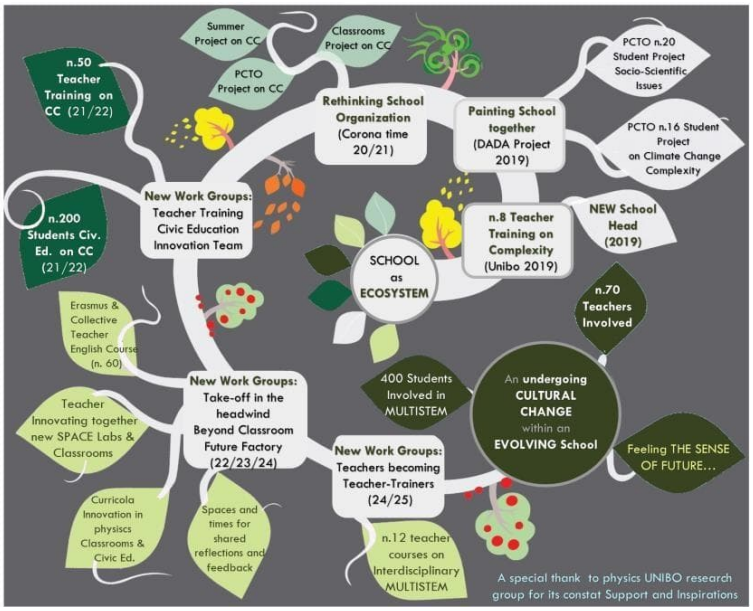

Figure1: Reimagine our School as an Evolving Ecosystem

The roadmap developed by IIS Baracca-Forlì comprises a series of interconnected strategies aimed at institutional transformation. Key steps include:

- *Redesigning Teacher Training Plans:* Establishing an internal training model that addresses genuine, shared needs while enhancing teachers' skills and professional roles. This includes maintaining connections with external stakeholders and leveraging impactful experiences to inspire innovation.

- *Creating New Organizational Structures:* Forming small, interconnected working groups focused on infrastructural, project-based and curricular innovation, as well as cross-disciplinary pathways and civic education.

- *Developing Flexible Environments:* Encouraging experimentation, active participation and shared experiences, alongside the creation of interconnected and integrated curricula.

- *Involving Students:* Actively engaging students in piloting new teaching practices and participatory approaches.

- *Fostering Reflection and Feedback:* Establishing opportunities for collective reflection and feedback among teachers to assess and guide the process of change.

These initiatives were designed to create a cohesive and responsive system capable of addressing the dynamic challenges of sustainability education.

HIGHLIGHTS AND CONCLUSION

By promoting a culture of collaboration and continuous renewal, IIS Baracca-Forlì has taken significant steps toward realizing the GreenComp objectives.

When the doors of a school building open, it is merely a container. The students, teachers, staff and leadership are like freshly planted trees. Simply being together in the same place is not enough for an educational ecosystem to flourish. Connections must be established, exchanges and interactions must take place, each individual must find their role and contribute to the collective well-being.

Much like a forest, where the roots of trees intertwine beneath the ground, a school is a place where experiences, knowledge and energy are interconnected and must be continually renewed. A mature forest doesn't grow overnight and neither does a school become an educational ecosystem in a day. Recognizing the need for change and building a shared vision is essential. It takes time, care and resilience. Most importantly, it requires valuing people by fostering a culture of interconnection, collaboration and mutual support among colleagues.

Transforming a school into a thriving educational ecosystem is a continuous journey of cultivating interconnection, collaboration and shared growth. It involves reimagining schools as vibrant communities where the seeds of the future are nurtured every day.

The roadmap developed by IIS Baracca-Forlì offers a practical and scalable model for aligning education with the demands of the GreenComp framework. By prioritizing systemic change and fostering a culture of collaboration, this vision provides a blueprint for schools to evolve into dynamic ecosystems, empowering both students and educators to tackle the challenges of sustainability in a rapidly changing world.

ACKNOWLEDGEMENTS

A special thank goes to all teachers of IIS BARACCA who collaborate with us daily.
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ADOPT A TREE

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Keywords: Plant Communication, Voltage, Internet of Trees.

ABSTRACT

The aim of the project is the construction of an extended tree network (IoT=Internet of Trees) which will provide the means for protection and conservation of one of the most precious but permanently endangered natural resources, our forests. This is achieved through the assembly, programming and installation of a remote data logger on an “adopted” tree within a forest or a city park. The device records several environmental parameters and their influence on the tree health, and either stores the data locally, to be periodically retrieved, or transmits the telemetry in real time via radio frequencies to the base station (school or elsewhere).

INTRODUCTION

Climate change is one of the greatest modern threats to the environment and human life. The importance of trees in combating the devastating effects of climate change on our lives is constantly emphasized by scientists. But how much do we really understand it? In a survey that was done asking young students to draw their town, most of them forgot to include one element in their drawing, trees. This phenomenon (green blindness) shows that they pass them by as if they can't see them.

In an effort to understand a little more about the physiology of trees and to encourage young students to notice them, we created a potential difference recorder between the tree trunk and the soil.

The potential difference is believed to occur due to the sap of the tree carrying salts and nutrients to all parts of the tree through its vascular system. When the plant is stressed for any reason this is recorded as a change in potential difference and alerts us to take care of it.

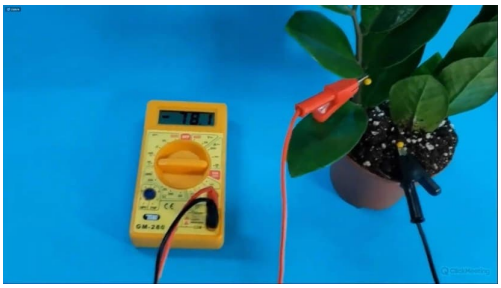

Figure 1: Measuring the potential difference between the plant stem and the soil

The logger is programmed to collect various environmental parameters and keep the data in a database so that the data collected can be processed. The ultimate goal is to create a network of trees that could alert to changes and help protect a valuable natural resource, our forests.

DESCRIPTION

Our hypothesis is that the health of a tree is directly related to its sap flow, which is driven by transpiration. This makes sense as tree sap has all the nutrients and water a plant needs to survive. A plant relies on its vascular system to take in nutrients and water through its roots and transport them to all its parts. This transport can be achieved through the process of transpiration. During this process, water is taken up by the roots together with the dissolved chemicals that form the plant's food. Through transpiration water is lost from the mouths of the leaves creating negative pressure and in this way water travels the entire length of the plant and can reach even up to 11 meters in height. The nutrients contain ions such as K+, Na+ which create the potential difference recorded.

Figures 2 & 3: Application of the data logger on an indoor plant and an outdoor tree.

Measuring the voltage between an electrode placed on the ground and another electrode placed on the trunk. This voltage is probably caused by the pH difference between the nutrient and salt solution in the soil and the sap in the trunk. The differences in voltage under certain environmental conditions for a number of thriving trees measured will be used as a basis for comparison with those of our adopted peers.

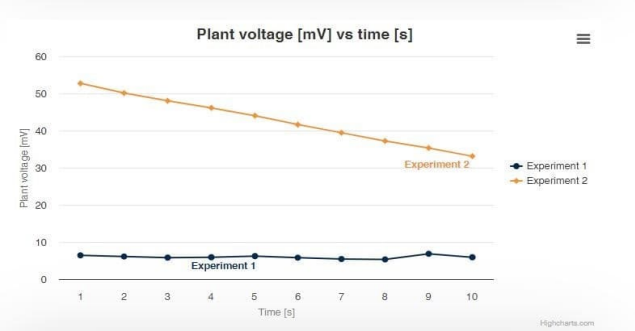

Figure 4: Experiment carried out in a classroom: Recording of potential difference data under different ambient light conditions
(Students set up and use a low-cost time-lapse based "data logger")

To collect a wealth of data the students created an Arduino-based data logger that, in addition to the potential difference, collects data on ambient temperature, humidity and brightness via sensors, which can be analysed and correlated with potential difference and plant health in a second time. For more details, you can refer to the Adopt a Tree page of Science on Stage Europe.

ACKNOWLEDGEMENTS

This work was supported by Science on Stage Europe as part of the project "Sustainability- Act Now", it is available on their site as teaching material and is currently implemented in primary and secondary schools across 35 countries.

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CLIMATE CHANGE EDUCATION USING A HOLISTIC PEDAGOGICAL APPROACH

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Keywords: climate change, Holistic teaching approach, GreenComp.

INTRODUCTION

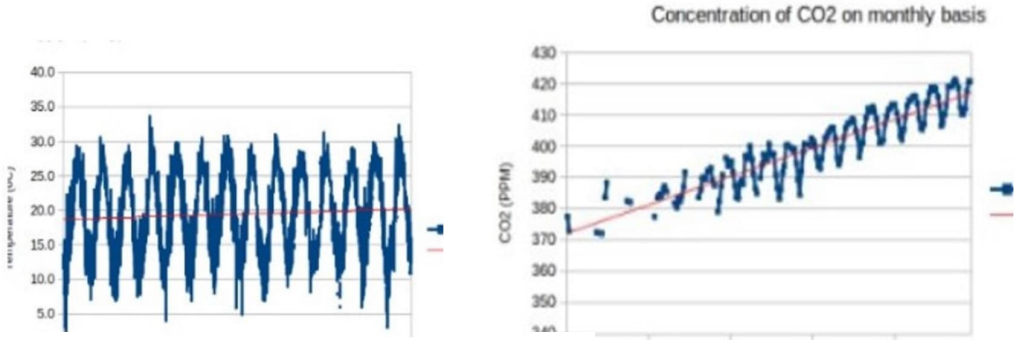
The accelerating impacts of climate change demand an educational shift to equip individuals with the knowledge and skills to address sustainability challenges. Traditional educational models, often disconnected from real-world issues, fall short in fostering transformative learning for climate action. A holistic pedagogical approach, integrating cognitive, emotional, social, and environmental dimensions, provides a framework for engaging students with climate change (Sterling, 2001). It emphasizes critical thinking, emotional resilience, and ethical responsibility—key elements in confronting global challenges. The GreenComp framework, developed by the European Commission, focuses on core sustainability competences: systems thinking, future orientation, responsibility, and problem-solving (European Commission, 2022). Aligning education with GreenComp offers a competency-based approach to climate change education. In the CLIMADEMY Erasmus Project**,** our school developed interdisciplinary learning plans integrating climate change education and GreenComp, supporting educators in developing the skills to promote sustainability. Through experiential learning, the project empowers students to engage with climate challenges (UNESCO, 2020). This study investigates how climate change education, holistic pedagogy, and the GreenComp framework in the CLIMADEMY project equip educators and students with competences for meaningful climate action, contributing to a more sustainable and climate-resilient future.

METHODS

In this section, we describe the methods used in the CLIMADEMY project to help students understand the complexity of climate change. A mixed-methods approach, combining qualitative and quantitative data collection, was used to assess the effectiveness of integrating GreenComp and STEM education in the classroom. Natural sciences and technology teachers collaborated to design interdisciplinary learning plans focused on climate change education. Students were first introduced to climate change in their Geology-Geography course, where they engaged with videos and gathered information to understand the climate system. This knowledge was further expanded through a visit to the Greek Hub at the Finokalia station, where 25 students interacted with scientists and observed real-time data collection. The visit provided hands-on learning experiences, allowing students to conduct experiments and listen to presentations. These activities deepened their understanding of the climate system and its real-world impacts while the trained students shared their findings with peers, fostering collaborative learning.

Figure 1: Group of students visiting the Greek Hub (left), Presenting experiments by trained students to their peers (right).

In Technology class, students used real data from the Greek Hub to create a time series on CO_2 concentrations (Figure 2b) and air temperature (Figure 2a), enhancing their data analysis and teamwork skills. In Geography-Geology, they analyzed this data and compared it with international research. In Social Science, students explored the socio-economic impacts of climate change. This interdisciplinary approach strengthened their critical thinking, data interpretation, and understanding of climate change in a global context while fostering essential skills in technology, research, and problem-solving.



a) b)

Figure 2 a) Time series of air temperature (blue line) from 2004 to 2017 on a daily basis at the Finokalia station, with the trend shown in the red line. b) Time series of CO2 concentrations (blue line) from 2002 to 2021 on a monthly basis at the Finokalia station, with the trend shown in the red line.

RESULTS

In this section, we present the results of the adapted methods implemented in the classroom, designed to foster both climate change awareness and the development of GreenComp competencies. Through their engagement in Geology, Geography, and Technology courses, students had the opportunity to investigate various phenomena related to climate change, such as ocean acidification and extreme weather events (e.g., floods). In addition, students were encouraged to observe local environmental phenomena and draw connections between these events and the broader effects of climate change. For instance, the school is in a rural area where most students come from farming families producing olive oil. Last year, these families experienced significant challenges due to a severe drought, which led to financial hardship. In their Social Science and History courses, students examined how climate change affects social and economic issues within their community and impacts their cultural heritage. This exploration aligns with GreenComp's focus on understanding the societal implications of environmental changes and developing the green skills needed to address these challenges. By adopting a holistic pedagogical approach to climate change education (Tolppanen et al., 2022), students not only deepened their understanding of climate change but also reflected on its effects at both global and local levels. This approach fostered the development of critical thinking, problem-solving, and social competences, equipping students to tackle climate-related issues in their communities and beyond.

CONCLUSIONS

This study explored how the CLIMADEMY Erasmus Project integrated climate change education, holistic pedagogy, and the GreenComp framework to equip both educators and students with competencies for effective climate action. Using a mixed-methods approach, we assessed the impact of these frameworks on student learning and engagement. Through interdisciplinary learning plans, students gained a foundational knowledge of climate systems in courses like Geology- Geography, and Technology. They then applied this knowledge through experiential learning, including a visit to the

Greek Hub at the Finokalia station, where they interacted with scientists and participated in hands-on experiments. This provided students with real-world data, such as air temperature and CO_2 concentrations, and enhanced their data analysis and problem-solving skills. The project also fostered a deeper understanding of the socio-economic impacts of climate change, developing students' systems thinking and critical analysis skills. Results showed that this approach significantly enhanced students' ability to interpret environmental data, collaborate, and apply sustainability competencies like responsibility, future orientation, and systems thinking. Integrating GreenComp and STEM education in the CLIMADEMY project effectively promoted climate literacy and green competencies, empowering students to engage in climate action and contribute to a more sustainable future.

ACKNOWLEDGEMENTS

This work was supported by the CLIMADEMY ERASMUS project and the Regional Directorate Education of Crete.

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FOSTERING CLIMATE CHANGE AWARENESS THROUGH DATA HUMANISM AND PERSONAL STORYTELLING: AN EDUCATIONAL APPROACH INSPIRED BY 'DEAR DATA'

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Keywords: Data-humanism, Data-visualization, Creative teaching methods

INTRODUCTION

This contribution presents the outcomes of a project inspired by teacher training experiences in Hyytiälä and Marathon. The work reflects the collaborative learning pathways co-designed with colleagues at Climademy and the creative input from my team at "Scuola delle Idee" in Bologna, a school using a STEAM approach. These activities aim to foster students' understanding of climate change through interdisciplinary, interactive, and reflective approaches.

METHODS

The project involved students aged 11–12 in lower secondary school over a 20-hour period. The activities were co-designed with the Art and English teachers, integrating preparatory work to familiarize students with the chosen methodologies.

Phase 1: Understanding Climate Concepts
Students began by exploring the concept of climate through local, national, and international articles and statistics, focusing on the relationship between human activity and climatic events. Working in groups of 3–4, they analyzed specific themes, presented their findings to peers in a "Journal Club" format, and engaged in discussions to deepen their understanding of climate change's complexities.
Articles were sourced from the website https://www.sciencejournalforkids.org. Key Competencies from Green Comp Framework: 2.1: Systemic Thinking 2.3: Problem Frameworks.

Phase 2: Data Collection and Visualization
Over four months, students collected personal data on water consumption at home and food waste in the school canteen. The data was visualized using Giorgia Lupi's "Data Humanism" approach, emphasizing storytelling to connect data with human experiences. Students created hand-drawn postcards in a "Dear Data"-inspired format, featuring visual representations of their climate impact and personal reflections, which were shared with a recipient of their choice. Key Competencies from Green Comp Framework: 3.3: Exploratory Thinking 4.2: Act for Change

An insight into data humanism and Giorgia Lupi's approach
Giorgia Lupi's "Data Humanism" advocates for making data relatable and human-centered. Rather than abstract charts, this approach uses storytelling and visual elements like dots, lines, and colors to convey data in an emotionally resonant way. By emphasizing the human stories behind data, this method fosters empathy and inspires actionable climate engagement.

WORKSHOP OVERVIEW

Objective: Engage secondary school teachers in a creative exploration of personal climate impact through hand-drawn data visualizations.

Steps:

- Introduction: Present the "Dear Data" project and its educational relevance.
- Reflection: Participants identified places where they observed climate change effects (e.g., melting glaciers, deforestation).
- Data Collection: Using a template, they recorded experiences related to climate impacts.
- Visualization: Participants translated their data into creative visual elements (dots, lines, shapes).
- Postcard Creation: Designed and shared postcards with visual data and reflections.
- Discussion: Explored applications for classrooms and shared feedback.
- Outcomes: Participants valued the blend of creativity, data, and environmental awareness, noting the potential of personal narratives to deepen understanding and inspire action.

CONCLUSION

The conclusion of the project emphasizes the innovative integration of personal narratives with data visualization, inspired by the "Dear Data" approach. This creative method demonstrates the power of storytelling in education, particularly as a tool to enhance awareness of climate change. By connecting personal experiences to global challenges, the visualizations produced were not only unique and meaningful but also deeply impactful. Furthermore, the project highlighted the potential of creative data representation to actively engage students, fostering their understanding and inspiring them to take concrete actions toward addressing climate change. A similar work was proposed during the international teachers meeting held in Bologna in the summer 2024.

Biographies

BIOGRAPHIES OF THE PRESENTERS AT THE CLIMADEMY FINAL CONFERENCE AND TCCF 2025

(in alphabetical order according to the first name)

Anastasia Papakonstantinou is a teacher in secondary education, with a degree in Biology, a master's in Environmental Biology (MSc), and a master's in Education (Med). She has been teaching since 2002 and in public schools since 2014. Currently, she also works in the first EKFE of Heraklion, training teachers and students in Biology experiments and environmental issues. She has participated with students in many volunteer programs and awarded projects. In 2023 she integrated a team in the "Save Nature by Understanding it" programme by Science on Stage Europe. In 2024 her students won 1st place in the European contest for Sustainability & Future League, and her project "Acid Rain, is it Pain?" was the winner at the Festival for STEAM Education of Science on Stage Europe in Turku Finland.

Andrea Cingolani is a chemistry teacher at IIS Corinaldesi Padovano, in Senigallia, Italy. He graduated in Chemistry from the University of Bologna and is doing his PhD with a focus on Green Chemistry and Green Catalysis. He has international experience through Erasmus programmes in the UK, Germany, and Canada, and as a co-designer teacher in CLIMADEMY.

Astrinos Tsoutsoudakis holds a BSc in Physics and MEd in e-learning. He currently coordinates the 1st Laboratory Center for Science Education of Heraklion, aimed to support primary and secondary school teachers. He voluntarily organizes classes for underprivileged and gifted students and mentors teams participating in STEAM competitions with numerous distinctions. He proudly possesses the title of one of the 7 international ambassadors of Science On Stage Europe, one of the largest STEAM teachers' networks from over 35 countries. He has contributed to the production of several teaching materials on Coding, Sustainability, and Quantum Computing.

Athanasios Dimou is a Land Surveyor and Engineering of Geoinformatics. He has in total 16 years of work experience, 10 (+ 6 months internship) as a freelancer and 6 years as a public employee (Geoinformatics engineer) in the Ministry of Culture Greece. He is a PhD candidate in the university of Aegean Mytilene Greece. He was President of the Panhellenic Association of Graduate Engineers of Geoinformatics and Topography for 6 years. He was and still gets invitated as a mentor in Greek and worldwide Hackathons (Nasa space APPS, MIT Hack, Copernicus, Green Tech etc). He also hosts The Geomentorist Podcast (spotify-youtube).

Athina Ginoudi is a physicist with a background in microelectronics. Her doctoral research was conducted at the France Telecom research labs in Lannion. She also holds a Master's degree in Adult Education. From 2011 to 2018, she served as a high school principal in Heraklion, Crete, and since 2018, she has been the science curriculum coordinator for the region of Crete. Her interests focus on innovative teaching methods, inquiry-based learning, STEM education, and real-world applications of science. She has co-authored over 100 publications in physics and education and has participated in numerous national and European research and educational project

Barbara Teodorani has been a Physics and Laboratory teacher in upper secondary school for about twenty years and since 2017 she has been working at the F. Baracca Aeronautical Highschool in Forlì, Italy. She is part of the innovation team and works closely with the teacher training coordinator at her school. She has carried out numerous educational initiatives both on STEM topics of social interest (such as climate change, artificial intelligence, and complexity education) and on more strictly curricular ones. Since 2018, she has been collaborating with the physics research group from the University of Bologna, actively participating in Erasmus + EU projects.

Eirini Varotsou is a Geology-Geography teacher at the secondary school in Arkalochori, where she has been working for the past four years. She completed her PhD at the University of Hamburg, with a dissertation focusing on transport variability and the driving mechanisms in the Flemish Pass, located at the

western boundary of the Subpolar North Atlantic. Over the past three years, she has also participated in the CLIMADEMY Erasmus project.

Eleftheria Sotiriou is studying Physics at the National and Kapodistrian University of Athens. Her main research interests are space weather and solar physics. She is working at Ellinogermaniki Agogi as a science lab assistant while she is promoting the inquiry-based approach in primary and secondary school lessons. In September 2023 she received the second prize for her proposal for the transformation of the Lavrion center to a sustainable city (Climathon Lavrio organized by the Ministry of Energy and Environment). In 2024 she was involved in organizing the main national event of World Space Week on the topic "Space and Climate Change".

Emma D'Orto is a PhD student in the Physics Education research group at the University of Bologna. She holds a bachelor's degree in Physics, a master's in Science Communication, and a master's degree in Physics Education. Her doctoral research focuses on investigating the role of narrative thinking for climate change education. Beyond academia, Emma is a science communicator and content creator, with a portfolio that includes filmmaking, animation, graphics, photography, and podcasting.

Francesco Martinelli is a science communicator, who works in journalism, communication, and science education on topics related to biodiversity, conservation, and climate. He has written for National Geographic, the New York Times, Nature, and others. He is among the founders of Happennino - festival and Radar Magazine. He has been collaborating with Fondazione Golinelli since 2016, as a trainer of teachers.

Giorgia Bellentani, with a background in sociology and management, has been heading educational and didactic projects since 2002. As Program Manager of Fondazione Golinelli's Educare a Educare, the area dedicated to the formation of teachers and the stakeholders of the educational system, Giorgia plans and coordinates courses and educational events. She also curates internationalization projects for Fondazione Golinelli. Within the scope of Climademy, she supervises, supports and facilitates the management and coordination of the Italian Hub.

Giovanna Lombardo (MA, PhD) has taught at various Italian universities and study-abroad institutions, as well as at the Italian Institute of Culture in Paris. She has published several essays and monographs on contemporary Italian literature. She teaches in a lower secondary school in Milan and is an author and consultant for educational publishing.

Giulia Tasquier is a senior research fellow in Physics Education at the Department of Physics and Astronomy of the University of Bologna and coordinator of the ENCOMPASS project. She is a member of the ESERA executive board and she was the conference manager of ESERA 2019. Her research expertise includes design and implementation of innovative teaching materials on modern physics and socio-scientific issue (e.g. climate change); the correlation between knowledge and behaviour in climate change; the role of epistemological knowledge on models and modelling in teaching/learning physics; qualitative methods of data analysis; development of strategies, tools and activities for transforming scientific knowledge into transversal skills about future; open-schooling. She was the coordinator of the open schooling network in Bologna for the Horizon2020 projects SEAS and FEDORA and she is now one of the referent for the Italian hub within CLIMADEMY.

Guia Bianchi is a researcher at the Joint Research Centre in Seville of the European Commission. Her main research interests include competencies and skills for green and digital transitions, and innovation policies. She is one of the co-author of GreenComp and Sustainability competences, describing research done so far on sustainability competences, green skills and skills for the circular economy. She is also working on innovation for place-based transformations, where she coordinated the publication on taking action for transformative innovation policies. She has a PhD in Sustainability Management and a Fulbright scholarship for research in circular economy.

Iina Hyyppä is a doctoral researcher at the Faculty of Educational Sciences, University of Helsinki, working with the TEFF Teacher Academy on developing a Digital Learning Module on Sustainability Education to be implemented into teacher education systems. Building on the work within TEFF, she is doing her doctoral dissertation on future thinking skills and agency beliefs in educational contexts.

Janina Taurinen is a doctoral researcher in the Education Research and Development Team at the Institute for Atmospheric and Earth System Research, University of Helsinki. Janina's study background is in the field of meteorology, but currently, their research revolves around climate change competencies and young people in Finland.

Jari Lavonen is an Emeritus Professor of Physics and Chemistry Education at the University of Helsinki, Finland. He has been working as a director of the National Teacher Education Forum and Chair of the Finnish Matriculation Examination Board. He is a member of the Finnish Academy of Science and Letters, a Distinguished visiting professor at the University of Johannesburg, and a Visiting professor at the University of Tartu. He has been researching science and teacher education for the last 34 years. His publications include 161 refereed scientific papers in journals and books and 185 books for science teachers and science education.

Jarmo Lehtinen is a history and social studies teacher at Lempäälä High School, in Finland. He has been teaching for about a quarter of a century. In his perspective, schools prepare children and young people for their future lives. Students should therefore be equipped with knowledge and skills that will help them dare to be themselves, want to develop their skills, be aware of their own potential for influence, and want to be part of building a sustainable future. In 2018, Jarmo and his colleagues founded the Climate Warriors group with young people. The goals of the Warriors are to convey information, influence things near and far, inspire action, and spread hope.

Jasmin Helnwein specializes in the complex interplay between human activities, climate change, the natural environment, drawing on her background in nature conservation and biodiversity management. Her expertise lies in life cycle analyses and microclimate simulations, focusing on the environmental impact of sustainable urban transformation.

Juan-Miguel Diaz Castro is a seasoned educator with over two decades of teaching experience. He currently works at the University of Oulu, in the Faculty of Education and Psychology as an Educational Development Specialist. He is a key contributor to the EU-funded TESTEd project, focusing on developing a syllabus that integrates themes such as sustainability, democratic education, gender sensitivity, multilingualism, and digitalization. His research interests encompass teacher education, curriculum development, and inclusive pedagogies.

Juliana Friedrichsen is a doctoral researcher at the Institute for Atmospheric and Earth System Research, University of Helsinki. Her research focuses on teachers' professional learning in climate change education. She holds a bachelor's degree in Biology and a master's in Sustainability Education. She has experience as a STEAM educator in international schools in Brazil and sustainability projects in higher education in the EU, including the coordination of the CLIMADEMY project.

Katja Anniina Lauri works as a research director at the Institute for Atmospheric and Earth System Research (INAR) at the University in Helsinki. She serves as deputy director of the institute in charge of education in atmospheric sciences. She received his PhD in aerosol physics from the University of Helsinki in 2006, but has after her PhD focused more on inter- and transdisciplinary research involving atmospheric and environmental sciences, but also social sciences and pedagogy. She has designed, coordinated and led several local, national and international education programmes and projects on MSc and PhD level. She has designed and taught numerous courses and organized several workshops, special sessions and other events in multidisciplinary environmental issues, pedagogy, and science outreach. She has served as the president of the Finnish Association for Aerosol Research (FAAR), and is a member of the European Geosciences Union (EGU), Nordic Society for Aerosol Research (NOSA), and Finnish Physical Society (FPS).

Kostis Chalkiadakis has been a secondary education Science teacher since 1998. He holds a degree in Physics and a Master's in ICT in Education. Since 2018, he has been the Head of the Science Laboratory Center in Rethymno. He is part of the editorial team of Eureka, a science education journal. He trains teachers in Digital Technologies and Physics curricula and has participated in STEM-related EU projects. He has presented at educational and research conferences and received awards in the Science on Stage competition. He is the Greek ambassador of Phyphox and Crete's ambassador for ESERO, the educational branch of the European Space Agency.

Labani Kanyonga Dr. Kanyonga works as a lecturer at Arusha Technical College. Dr. Kanyonga holds a PhD in Educational Research and Evaluation, a Master's of Education in Assessment and Evaluation, and a Bachelor of Education in Science (Chemistry) from Moi University, St. Augustine University of Tanzania, and the University of Dar es Salaam, respectively. Dr. Kanyonga has research interests in climate change education, students' engagement in scientific experiments, inquiry-based learning, problem-solving skills, the development and assessment of scientific inquiry competencies, and the use of design-based thinking in educational contexts. Dr. Kanyonga is now engaging in writing research proposals for funding in the area of inquiry-based learning and climate change education.

Laura Riuttanen is a university lecturer in atmospheric sciences at the University of Helsinki Institute for Atmospheric and Earth System Research. She is a founder and lead of Climate University, a network of 28 Higher Education institutions in Finland. She has long-term experience in the development of climate education in higher education, online education and teacher education.

Lorenzo Miani is a researcher in climate change education in the Physics Education research group at the University of Bologna. He holds a bachelor's degree in Physics and a master's in Physics Education. His doctoral research focused on the role of uncertainty in developing sustainability competencies following a future-oriented science education approach to climate change.

Maija Aksela is a professor of science education and teacher educator at the University of Helsinki. She is a founder and director of the International Teachers Climate Change Forum (TCCF). One of her research interests in climate change education. She has been a director of the national LUMA (STEM) Centre Finland (2013-25) and promoted the LUMA work nationally and globally since 2003. Nowadays she works as LUMA Science Ambassador beside her main work. She has published over 400 publications and received 18 recognitions: eg. the Nokia Award, Scientist of the Year, and a Teacher Award.

Maria Kanakidou is a Full Professor of Computational Environmental Chemistry, Head of the Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, a visiting Professor at the Institute of Chemical Engineering Sciences of the Foundation for Research and Technology-Hellas, Patras, Greece, and currently holds a Chair of Excellence at the Institute of Environmental Physics, University of Bremen. She is a member of several international scientific committees on atmospheric and marine environment and climate (GESAMP-WG38, ICACGP, SOLAS, WMO/MMF-GTAD). She was awarded the Vilhelm Bjerknes European Geophysical Union Medal for Atmospheric Sciences and the von Humboldt Foundation Medal for Atmospheric Sciences. Her main interests concern: atmospheric composition and climate change, human and ecosystems' health and air-sea interactions. She is the coordinator of the CLIMADEMY project.

Marjo Vesalainen (PhD) works as a Senior Ministerial Adviser in the Department for Higher Education and Science Policy at the Ministry of Education and Culture in Finland. Her work focuses, broadly speaking, on questions related to teacher education, sustainable development, STEM strategy, and minority languages in the context of higher education. Before joining the Ministry of Education and Culture in 2020, Marjo worked at the University of Helsinki for over 20 years.

Markku Kulmala is Professor at the University of Helsinki and Academician. He is a world leader in atmospheric aerosol science and one of the founders of "terrestrial ecosystem meteorology". He has led the Institute for Atmospheric and Earth System Research INAR since it was founded in 2017. He leads the

Atmosphere and Climate Competence Centre ACCC Flagship of the Research Council of Finland. He has published over 1240 original research papers, of which 39 in Nature and Science. His H-factor is 140. He has supervised 85 doctoral theses and 54 master's theses. 45 of his former students have (or have had) permanent professorships or tenure track positions in academia. He has received two ERC Advanced Grants and more than 40 national and international awards and honours. The backbone of his research consists of SMEAR (Stations for Measuring the forest Ecosystem – Atmosphere Relationships) field stations.

Mélanie Michel With a background in international relations, environmental technology and economics, Mélanie Michel specializes in intersectional urban development, focusing on how climate strategies enhance resilience and address diverse community needs. Their research examines how various factors combine to strengthen resilience and foster social cohesion.

Merja Kuisma is an experienced biology and geography teacher from Pirkkala, Finland. She holds a PhD in Education, and her work with young people has been recognized and awarded in Finland. She is a birdwatcher and has a deep respect for biodiversity. As a teacher, building hope is at the center of her profession. Her goal is to strengthen students' lifelong relationship with nature and understanding of sustainability.

Michela Clementi has been a Physics teacher in upper secondary school for about twenty years and since 2012 she has been working at the Scientific Lyceum "A. Einstein" in Rimini, Italy. She has been collaborating for a long time with the Physics research group from the University of Bologna, engaging in educational activities, such as the development and implementation of educational paths in classical and modern physics, taking care of conceptual and epistemological reflections. Since 2016, she has also been involved in European projects in partnership with the University of Bologna, working as a research teacher in fields such as artificial intelligence, quantum computing, and climate change. She has been vice-principal in the Liceo Einstein for the next two years; in this role, he continues to be involved in teaching, trying to foster an innovative environment of interdisciplinary cooperation.

Nikos Kalivitis holds a degree in Physics, an MSc, and a PhD in Chemistry. His doctoral research focused on the climate-relevant properties of atmospheric aerosols in the eastern Mediterranean. He is currently a researcher at the Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete (UoC). With over 20 years of experience in environmental monitoring and research infrastructure management, his scientific interests include atmospheric aerosols (formation mechanisms, physical and chemical properties), air quality, and their impacts on public health and climate change. He is actively involved in climate change education. He is a Fulbright Scholar.

Olivia Levrini is a Full Professor of Physics Education at the Department of Physics and Astronomy A. Righi at the University of Bologna, where she is responsible for the curriculum in Epistemology, History, and Didactics of Physics. She is a Section Editors of the journal Science Education and she was Associated Editor of the journal Science & Education. She is SIG's coordinator and strand chair of ESERA and she was the Conference President of the ESERA 2019 conference (Bologna, August 26-29, 2019). She coordinates the projects FEDORAS (2025-2028), FEDORA (2020-2023), IDENTITIES (2019-2022), I SEE (2016-2019). She was responsible for the Bologna unit of the projects SEAS and RAISE (KIC-Raw Materials). Her main research interests currently concern: interdisciplinarity in STEM education; futures thinking; identity and processes of appropriation; and scientific languages.

Philippe Kobel Dr. Philippe Kobel is the founder and coordinator of Graasp Climate (climate.graasp.org), a Swiss-based project that creates simulations and interactive activities to teach global warming in physics, chemistry, and biology, in order to provide tools for multidisciplinary teaching of the causes and consequences of global warming in basic sciences. He teaches physics in high school (Gymnase du Bugnon, Lausanne) with passion since 2014. In his teaching, he became interested in using numerical tools to empower students with more autonomy, creating a YouTube channel (PhilZiK) and numerical activities with the Graasp platform to guide students in discovering physical concepts at their own pace. For this work, he was selected for the HundrED Spotlight award in 2019 (see YouTube "Learning together yet

individually"). After a PhD in solar astrophysics in 2009 (University of Göttingen/Max-Planck Institute), he already launched another educational worldwide programme - GalileoMobile (galileomobile.org) - to visit schools in various countries (South America, India, Ouganda, Cyprus) with a team of young astronomers to perform playful instructive activities about the Cosmos with the motto "Under a same sky".

Stefania Zampetti is a Medical biotechnologist with a PhD in Biodiversity and Evolution with an anthropological focus. She is part of the staff of Fondazione Golinelli, where she deals with educational planning for students and training courses for secondary school teachers. She teaches science at Scuola delle Idee, a secondary school where she takes care of enhancement projects that combine digital, science, and humanities. She is also a co-designer teacher of the European Climademy project.

Taina Ruuskanen is a senior university lecturer working at the Institute for Atmospheric and Earth System Research (INAR) at the University in Helsinki. Her research background is in atmospheric particle formation and the release of aerosol precursors from biospheres. She completed a PhD in physics in 2009 and was the Director of Physics Bachelor in Science degree program 2018-2024. She is currently the director of a Specialisation programme in climate expertise and over 20 years of experience in developing and teaching university courses, supervised four completed and two ongoing PhD theses. Taina has participated in organizing the Teachers Climate Change Forum (TCCF) since the start of it in 2017 and her current research interests are in climate change teaching and learning.

Tarja Halonen served as President of Finland from 2000 to 2012. Prior to her election, she held the office of Minister of Social Affairs and Health, Minister of Justice, and Minister for Foreign Affairs. During her career, President Halonen has paid close attention to issues of human rights, democracy, civil society, gender equality, and sustainable development. Among other duties, President Halonen is currently a member of the UN's Secretary-General's High-Level Advisory Board on Mediation and UNCCD Land Ambassador.

Thalia Tsaknia has been working at the educational institution of Ellinogermaniki Agogi since 2007, having long experience in science education, instructional design, and curriculum development. She has been involved in the design and implementation of various STEAM, skills development, and environmental education programs and activities, and she is the author of the inquiry-based environmental textbooks used at the school of Ellinogermaniki Agogi. She has worked for teachers' upskilling and training and participated in several EU research projects related to different learning approaches and advanced technologies in science education. She holds a B.Sc. in Physics and an M.Sc. in Electronics and Telecommunication Systems.

Topias Ikävalko, MSc in chemistry education works as a science education specialist at the University of Helsinki. He is also a doctoral researcher focusing on transition in higher education and collaboration between higher education and upper secondary education. Topias has participated in organizing the Teachers Climate Change Forum (TCCF) since 2019.

Veronica Ilari holds a master's degree in physics from the University of Bologna. Her studies explored the temporal structures of the science of complex systems, comparing them with those of classical Newtonian physics. She is currently a research fellow in the Physics Education research group at the University of Bologna, led by Prof. Olivia Levrini. In this position, she is involved in co-designing and co-teaching activities at the Liceo Scientifico e Musicale "A. Einstein" high school in Rimini, part of the Italian HUB of the European project CLIMADEMY.