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Good Practices Guideline Handbook for Climate Change Education

- Extended Version -

ΙΔΡΥΜΑ ΚΡΑΤΙΚΩΝ ΥΠΟΤΡΟΦΙΩΝ IKY

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Development of a Good Practices Guideline Handbook for climate change education with IBL, gamification and digital teaching methods

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Preface

According to UNESCO, "Education is crucial to promote climate action. It helps people understand and address the impacts of the climate crisis, empowering them with the knowledge, skills, values and attitudes needed to act as agents of change."

In this regard, a teacher's role in developing climate change awareness is crucial. The ClimaTePD project's overall goal is to help in-service secondary teachers in developing digital literacy and climate change teaching skills as means for enabling their students to build awareness about the global threat of climate change.

Within the pages of this handbook, we embark on a dual journey, weaving together threads of tradition and sustainability. Development of a Good Practices Guideline Handbook for Climate Change Education with IBL, Gamification, and Digital Teaching Methods provides a guiding light in the realm of climate change education. It marries the enduring legacy of hanbok with the urgent call for environmental stewardship.

Through meticulous research and insightful contributions, this handbook offers a comprehensive exploration of the evolving landscape of climate change education. From the foundations laid by the ClimaTePD programme to the interdisciplinary competences required for sustainable development, each chapter is a step towards a more informed and engaged global community.

Practical steps to implement Climate Change Education in classrooms, coupled with innovative learning experience designs, illuminate the path forward. The community-building skills of teachers emerge as pivotal in uniting stakeholders for a collective response to climate change.

As technology continues to reshape the educational landscape, Chapter 5 guides us in constructing an e-learning platform tailored to the needs of teachers. Chapter 6 introduces the power of Design Thinking, providing a framework for the effective implementation of climate change education.

In the pages that follow, we invite you to explore the juncture of tradition and progress, where the threads of hanbok and the call for environmental consciousness converge. Together, let us embark on a journey towards a more sustainable and harmonious future.

Chapter 1: Climate Change Education and the ClimaTePD Programme

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Abstract: The first chapter of the "Guideline Handbook for teachers' good practices and competences development on climate change, IBL, gamification and digital teaching methods" makes a reference to the severe problem of the climate crisis and how climate change education comes to promote the awareness on the topic and indicate possible approaches to cope with this threat. Apart from the multi-faceted nature of climate change education and the challenges that teachers usually face while they are teaching climate change, the state of affairs regarding the embedment of climate change and digital teaching skills into TPD (Teachers' Professional Development) schemes and secondary education in the ClimaTePD consortium counties (Greece, Spain, Germany, Bulgaria and Turkey) is also presented. At the end of this chapter, a section about the pedagogical approaches and the digital competences that teachers should acquire to teach climate change topics is included.

Introduction

The climate crisis remains one of the world's greatest concerns, which affects air, water and land and has a severe impact on all aspects of our lives. It also increases the risk of resilience, financial and political instability, environmental degradation and social tensions (https://www.britannica.com/science/pollution-environment). Environmental pollution is firmly connected with urbanisation, industrialisation, mining and exploration and the long-term damage caused to the environment is the main reason for global warming (Ukaogo, 2020, Rai, 2016).

According to the "2030 Agenda for Sustainable Development" of the United Nations (UN), it is critically important to protect the natural capital and the planet as a whole, by building a sustainable future, inspiring action and fostering influencing skills among the people. This framework includes 17 Sustainable Development Goals (SDGs) which are connected with key areas in order to support sustainable development. The 13th SDG refers to the climate action and the strategic plan to fight climate change and its consequences on the planet and the citizens (United Nations, https://sdgs.un.org/goals). A specific Target 13.3 of the 13th SDG focuses on the improvement of *"education, awareness-raising and human and institutional capacities on climate change mitigation, adaptation, impact reduction and early warning"* (United Nations, 2015, United Nations, n.d.).

As the climate crisis is also correlated with education, UNESCO asserts that education is a key element for addressing the challenges posed by climate change. Education equips people with the knowledge they need and encourages behavioral changes to help them cope with this significant environmental issue. It also raises awareness in a vast audience including teachers, students and their families and the society at large and enhances citizens' "climate literacy". UNESCO also

suggests that climate change should be included in the TPD programmes to support teachers in climate change teaching and skills development (Maki & Crosier, 2019, Unesco, n.d.).

Climate Change Education

Climate change education can easily create a general shift in people's thinking and action at all levels of society, which are the key points for sustainable development and for a better life for all (Becker, 2018). Although climate change constitutes an extremely high priority topic, it seems that it has not been integrated yet in the schools' curricula of many European countries.

Many organisations, including UNESCO, UNEP, UNICEF, Plan, Save the Children, and ActionAid, are working toward integrating climate change into school curricula. Meanwhile, the Intergovernmental Panel on Climate Change (IPCC), the UN body responsible for assessing science related to climate change, provides valuable guidelines and educational materials on the subject (IPCC 2014, p. 27; Reimers, 2021).

It is important to mention that it is crucial to "vaccinate" the school's curriculum with climate change education, which cultivates the profile of the responsible citizens of the future (Maki & Crosier, 2019). Teachers play a unique role in the embedment of climate change education in school curriculum, which is more than crucial for this transition. Climate change education not only helps students to gain knowledge about the climate crisis and find ways to deal with it, but also inspires them to follow a more participatory and active approach in their everyday lives.
https://www.globalpartnership.org/blog/blog-series-role-education-addressing-climate-change

The majority of the teachers consider climate change as a very challenging subject because it is mainly science-based, but there are many topics that are based on social behaviour and activism, equality and social organisation. Another barrier that teachers face in teaching climate change is its multidisciplinary nature, along with the limited availability of free and easily accessible resources. Additionally, there is often a lack of professional guidance, support from experts or mentors, or training schemes specifically focused on climate change.

Training in climate change education should also focus on the development of teachers' digital literacy for several important reasons:

1. **Resource Access**: A lot of climate change information and teaching materials are available online. Being digitally literate allows teachers to efficiently search for, access, and evaluate these resources.
2. **Up-to-Date Information**: Climate science is a rapidly evolving field. Digital literacy enables teachers to keep up with the latest research and news, which they can then incorporate into their teaching.

3. **Interactive Learning**: Digital tools offer interactive methods for teaching complex topics like climate change. For instance, digital simulations can help students grasp the impact of different variables on climate systems.
4. **Global Perspective**: Understanding climate change requires a global perspective. Digital literacy can help teachers and students access international data, communicate with experts or peers from around the world, and understand local impacts in a global context.
5. **Online Collaboration**: Being digitally literate allows teachers to collaborate with other educators and experts, share resources, and perhaps even co-create educational material focused on climate change.
6. **Pedagogical Innovation**: Digital literacy equips teachers with the skills to implement more innovative pedagogical methods, including flipped classrooms, online assessments, and gamified learning experiences, which can make the learning process more effective and engaging.
7. **Skill Development for the Future**: Besides the subject matter, digital literacy is also a critical skill for the workforce. Integrating it into any form of education prepares students for the future.
8. **Addressing Misinformation**: Digital literacy skills can help both teachers and students discern credible information from misinformation, an increasingly crucial skill given the prevalence of "fake news" surrounding climate issues.

Digital technologies are present in all forms of education and they are widely recognised in all the EU countries and they not only make the learning process more interesting, interactive and fun but also improves the teaching quality of education and especially topics that are highly participatory and engaging like climate change (Tsitopoulou, 2021, Najjar, 2015). The inter- and multidisciplinary nature of climate change education merged with digital tools and approaches could lead to the students' skills development in emotional, cognitive and social level (e.g., Liarakou & Flogaiti, 2007).

Climate Change Education in secondary school curriculum and in TPD schemes in the ClimaTePD consortium countries

ClimaTePD Erasmus+ programme funded project aimed at facilitating the dialogue in education and supporting the embedment of climate change education in schools curricula in order to inspire students to adopt environmental principles. Moreover, its main goal was to provide teacher training that supports secondary school teachers' digital literacy development in their climate change teaching and learning practice. Based on the information provided by the in-service teachers and educational stakeholders during the programme implementation in the consortium countries, many useful points about climate change education challenges are extracted.

In Bulgaria, climate change is not well integrated into the school's curriculum, but there are many teachers, organisations and researchers that implement activities about climate change at a local level. Climate change education still faces general negativism, prejudice and misunderstanding and lacks a solid research background.

In Germany, there is a significant level of engagement with climate change education, although it has not yet been widely implemented in all schools. Both teachers and students generally express positive attitudes toward including climate education in the curriculum. Despite the existence of the National Action Plan on Education for Sustainable Development since 2017, which spans various facets of the German education system—including teacher training, selected curricula, and some educational plans—climate education remains a challenging topic. As it stands, individual dedicated teachers and school administrators are primarily the ones addressing this critical issue in their curricula.

In Greece, climate change education is not yet part of the school curriculum but there are teachers, as well as environmental organisations and education centres that implement climate change projects for students. Climate change is not only described by scientific complexity by many Greek teachers but it is also considered as a very demanding topic. To address this issue, TPD programmes are essential in order to help teachers update their knowledge, improve their skills and develop their expertise to integrate interdisciplinary topics in their subjects that are interesting and are connected with the life experiences of the students.

In Spain, climate change education is not sufficiently developed in the school curriculum and that's why teachers face difficulties to implement it in their classrooms. It is positive though that teachers and school managers are free to elaborate their teaching schedule and incorporate climate change topics and activities in their subjects. The Spanish government also supports teacher training for sustainable development education and funds initiatives and organisations to develop activities relevant to climate change education.

In Turkey, climate change is addressed in several courses in teacher training and it is a hot topic both in formal and informal learning environments. There is a high demand, though, on best practices and resources about climate change teaching at schools which are very useful for the teachers.

In all the involved countries namely Bulgaria, Germany, Greece, Spain and Turkey the level of climate change education and its integration in the school curriculum is different, but the challenges are more or less similar, while the need for scientific and pedagogical guidance and competence development is highlighted by all the teachers and the educational stakeholders. The implementation of teacher training about climate change is of high importance, with innovative

teaching methods, interesting and updated educational material, inter- and multi-disciplinary and topics that affect people's lives, incorporation of digital tools and information about developing digital skills among teachers. It is a fact that schools need support, advice and networking opportunities and especially teachers need support on acquiring digital literacy in order to create their digital educational material and improve their digital teaching methods.

Pedagogical approaches and digital competences of the teacher training about climate change

Following the new era of the digitalisation of education it is essential for teachers to learn how to use digital tools in their classes and catch up with the digital transformation of the society. Teacher training should support teachers to develop a range of different skills, improve their collaboration and their communication with their colleagues and deal with heterogeneous groups of students (OECD, 2019, Nawaz, 2010). Focusing on the skills that should be included in TPD schemes about digital competences development, there are three areas that have been identified: 1) tools expertise, 2) subject-specific uses and teaching methods, and 3) literacy on digital culture and media (Aillerie, 2017).

Apart from the digital competences the second pillar which is very important for a TPD development is the pedagogical approaches that a training should be based on. The ClimaTePD teacher training is mainly based in two different active pedagogical approaches: Inquiry Based Learning (IBL) and Gamification, which are compatible for dealing with climate change education.

IBL has been used the last few years as an educational approach in STEM subjects and it is particularly contributing to the development of teacher's skills in TPD schemes essential for their professional life (Chaimala & Kikis-Papadakis, 2019). IBL is a form of active learning and students play the first role in the learning process. It facilitates the student's learning and at the same time they set their own questions, propose solutions and create their learning activities. Moreover, students, individually or in groups, examine the problem, create hypotheses, collect and analyse data and present their results, while the teacher holds the role of the facilitator. (www.igi-global.com/dictionary/inquiry-based-learning-ibl/14744; Silm et al., 2017). IBL also enhances the methodological competences such as integration of digital tools in IBL, proficiency in pedagogical methodologies, organisation skills, communication skills, leadership and analytical thinking as well as learning content competences such as design and development of research materials, STEM expertise, etc. (Stefanova et al., 2019).

Apart from IBL, Gamification promotes students' skills such as problem solving, personal autonomy, decision-making, cooperative learning that seems to be ideal for climate change teaching. The use of games to engage students keeps the balance between content and gaming and its application in the real world. Gamification improves students' engagement, effectiveness and efficiency of the learning process, especially in STEM disciplines and climate change education. Furthermore, the use of Gamification promotes communication skills, collaboration, creativity, critical thinking and problem-solving skills (Majuria et al., 2018, Manzano-León et al., 2021; Cózar-Gutiérrez & Sáez-López, 2016; Hanaysha, 2016).

To sum up, the ClimaTePD programme and teacher training could support teachers and introduce new contents and resources in the TPD schemes about climate change education. Additionally, the project can be a lever for helping in-service secondary teachers in developing digital literacy and climate change teaching skills as means for enabling their students to build awareness about the global threat of climate change.

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Chapter 2: Climate Change Education for Sustainable Development – Competences and Interdisciplinarity

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Abstract: This chapter situates Climate Change Education (CCE) within the framework of Education for Sustainable Development (ESD), emphasizing that CCE builds on and contributes to ESD goals. It highlights the need for transformative educational processes to address global challenges such as climate change. A key component is the identification and promotion of sustainability competences in learners. The article summarizes the GreenComp competence framework, outlining four competency areas, and provides an example to illustrate the complexity and interconnectedness of ESD issues, requiring an interdisciplinary, systems thinking approach. Furthermore, the paper outlines that CCE and ESD require contributions from all disciplines to develop 'climate literacy' and 'sustainability competences' and gives examples of how different subjects can contribute from their different perspectives to benefit from synergies. It also emphasizes the need for a holistic approach (involving all members of the school community) in order to embed sustainability in the school culture. For this purpose, exemplary measures for implementing the so-called Whole-School Approach are presented. It concludes that CCE embedded in ESD requires interdisciplinarity and a holistic approach to equip learners with competences to understand complexity, envision sustainable futures and take transformative action.

Introduction

Call for Action

Challenges of a global scale compel us to take action: Topics such as anthropogenic climate change and the associated problems like the exacerbation of social inequalities (see e.g. Beermann/Fischle 2021), the increase in extreme weather events, the rise in sea levels and the collapse of resources (see e.g. Club of Rome 2012) are now more prevalent and more intensely debated on a global scale than ever before. The possibility that humanity could face (these or similar) challenges in the long term was already described in 1972 in the study "The Limits to Growth" commissioned by the Club of Rome and published by the research team around Meadows at the Massachusetts Institute of Technology (MIT) (see Meadows et al. 1972). Globally, the realization is spreading that political, social and economic transformation is indispensable for the long-term safeguarding of our existence and that ecological sensitivity must underlie all forms of human action as a binding starting point.

2.1 Situating Climate Change Education (CCE) within the framework of Education for Sustainable Development (ESD)

Possibility for Action: Education as a Prerequisite for Promoting Sustainable Transformation Processes

Since Agenda 21 (see UNCED 1992) in particular, which in turn is based on the findings of the Brundtland Report (1987), national and international efforts for sustainable development have been observed at various levels. One of many ways to respond appropriately to the global challenges of our time is the promotion of sustainability through educational reforms. Thus, the

United Nations (2005 – 2014) proclaimed the World Decade of 'Education for Sustainable Development' (ESD) with the goal of implementing the principles of sustainable development in national education systems and thus building on the goals of Agenda 21 and promoting essential societal transformation processes. Here, education is considered "(…) critical for promoting sustainable development and improving the capacity of the people to address environment and development issues" (Agenda 21, p. 320).

Education for Sustainable Development (ESD) aims to empower young people to think and act in ways that allow them to develop to their full potential within ecological limits in the sense of sustainable development. It should sensitize young people to analyze and evaluate both local and global developments considering their effects on humans and the environment from an ecological, economic and social perspective and ultimately help shape societal life towards a sustainable future.

The knowledge required for this, and the development of corresponding values, skills and abilities should contribute to understanding interconnected global challenges (such as climate change processes, loss of biodiversity, unsustainable use of resources, inequality, etc.), making sound decisions and ultimately taking collective action participatively. Here, the "cross-cutting competencies [of ESD; E.L.] in cognitive, socio-emotional and behavioural dimensions of learning bear relevance to all areas of education" (UNESCO 2020, p. 14).

Climate Change Education for Sustainable Development (CCESD)

"(…) Education for Sustainable Development (ESD) has emerged as a cornerstone for tackling climate change" (UNESCO 2016, p. 2). Climate Change Education (CCE) builds on ESD (see UNESCO 2015, p. 12); thus, sustainable development goals that implicitly or explicitly relate to climate change/climate protection can already be found in various chapters of Agenda 21 (see e.g. Chapter 4: Changing consumption patterns, Chapter 9: Protection of the atmosphere, Chapter 11: Combating deforestation, Chapter 12: Managing fragile ecosystems: combating desertification and drought, etc.). 'Climate action' is one of the 17 global sustainability goals of Agenda 2030, and it is clear that climate protection (and thus the need for CCE) is in an interdependent relationship with other sustainability goals and should not be considered 'in isolation' as such (see Fig. 2.1).

Figure 2.1

17 SDGs of Agenda 2030

(Source: https://www.un.org/sustainabledevelopment/news/communications-material/ 31.08.2023)

CCE is based on similar (didactic) principles as ESD, but focuses on climate change. It requires engagement with scientific fundamentals (e.g. climate and climate system, greenhouse effect, etc.), with the causes and consequences of climate change (e.g. natural and anthropogenic climate change, global warming, ecological, social and economic impacts) and with measures to mitigate climate change and adapt to it (e.g. climate policy, individual and societal actions, etc.).

☛ **Climate Change Education for Sustainable Development** (CCESD) raises learners' awareness of the causes, consequences and dangers of climate change; by imparting the necessary knowledge, skills, values and attitudes, it enables them to understand climate change – promotes so-called "climate literacy" (UNESCO 2015, p. 12) –, deal adequately with the challenges, develop appropriate measures for sustainable climate protection and thus actively help shape societal life towards sustainable development (ibid.).

Initiating successful transformative educational processes requires a holistic approach at various levels, e.g. creating appropriate framework conditions through educational policy reforms, redesigning and enhancing teacher education programs at universities, providing advanced training for in-service teachers, fostering cooperation with external partners, and more. Finally, it requires the participation of all actors involved in the education sector: education policymakers,

teachers, university lecturers as part of teacher training, experts in curriculum development and external partners (see e.g. Gehlawat 2016, pp. 57 et seq.; UNESCO 2016, p. 3). Furthermore, and as one of the key issues in transformative educational processes, it is also necessary to identify and promote the competencies that young people need in order to be able to analyze current developments, anticipate and evaluate future (non-sustainable) developments, and act in the sense of a sustainable future. Thus, various competence models have been developed nationally and internationally, all of which pursue the goal of defining sustainability competencies, but which may differ slightly in their degree of concretization, target group or national framework conditions and resulting focus. The following chapter will present the competencies according to GreenComp (2022) as an example.

2.2 Competences of Education for Sustainable Development

The preceding sections have shown that Climate Change Education (CCE) builds on ESD and can thus be situated within ESD, which is why ESD competence models can be used for CCE. In order to achieve the objectives described above and to raise awareness among young people about climate change, its causes and consequences, young adults need a specific set of knowledge, skills, and attitudes that must be supported and promoted in school education. Specifically, CCE requires...

- "(…) knowledge of the history and causes of climate change; knowledge of and ability to distinguish between certainties, uncertainties, risks and consequences of environmental degradation, disasters and climate change;
- knowledge of mitigation and adaptation practices that can contribute to building resilience and sustainability; and
- understanding of different interests that shape different responses to climate change and ability to critically judge the validity of these interests in relation to the public good." (Anderson 2012, p. 194)

In recent years, various research groups have dedicated themselves to the question of the competencies that need to be promoted in education for sustainable development. As part of the 'European Green Deal' and the 'European Education Area by 2025', a European competence framework for sustainability was developed by the European Commission's Joint Research Centre (2022).

GreenComp is intended as "a reference framework on sustainability competences at EU level. It provides a common ground to learners and guidance to educators, providing an agreed definition of what sustainability as a competence entails. Such a shared understanding can act as a catalyst for learning for environmental sustainability by supporting education and training institutions to develop, review and adapt their vision and practices with regard to teaching and learning for sustainability." (Bianchi et al. 2022, pp. 6 et seq.)

GreenComp defines a number of so-called "sustainability competences" (Bianchi et al. 2022, p. 12) which, as part of international education programs, for example, should enable learners through the development of knowledge, skills and attitudes "(...) to embody sustainability values, and embrace complex systems, in order to take or request action that restores and maintains eco-system health and enhances justice, generating visions for sustainable futures" (ibid.). The competence model consists of four (competence) areas, each comprising three competencies:

Table 2.1:
GreenComp – Competences and descriptions (oriented to: Bianchi et al. 2022, S. 14 – 15)

Competence areas and sustainability competences	Short description
1. EMBODYING SUSTAINABILITY VALUES: 1.1 Valuing sustainability 1.2 Supporting fairness 1.3 Promoting nature	The first competence area focuses on **questioning, reflecting** on and ultimately also **developing attitudes and values** in line with sustainable development, with a view to humans as part of nature and consideration of intra- and intergenerational justice.
2. EMBRACING COMPLEXITY IN SUSTAINABILITY: 2.1 Systems thinking 2.2 Critical thinking 2.3 Problem framing	Social, economic and ecological developments in a **globalized world** are problematic, (often multiple) **complex**, show feedbacks and **dynamics**, which is why they cannot be adequately understood using linear thought processes (simple cause-and-effect relationships), e.g. socio-ecological problems such as climate change. A **holistic understanding of systems** against the background of their complexity and the ability to **identify unsustainable developments as a problem** are therefore an indispensable basis for all sustainability issues.
3. ENVISIONING SUSTAINABLE FUTURES: 3.1 Futures literacy 3.2 Adaptability 3.3 Exploratory thinking	This competence area describes the **ability to develop different (sustainable) future scenarios** and **appropriate measures for their realization** despite uncertainties and risks.
4. ACTING FOR SUSTAINABILITY: 4.1 Political agency 4.2 Collective action 4.3 Individual initiative	The fourth competence area **represents the need for individual and collective action** to help shape a sustainable future.

To illustrate the competence areas and corresponding sustainability competencies, the 2nd competence area 'Embracing Complexity in Sustainability' is presented as an example:

Sustainability issues are always multifaceted, complex in nature and often transcend national borders (e.g. climate change as a socio-ecological challenge), so the need for a global perspective comes hand in hand with greater complexity. The interlinking of different perspectives and dimensions of sustainability issues also increases this complexity. If, for example, one wishes to discuss **the effects of consuming animal-based foods such as meat on the climate**, (i. a.) ecological, economic and social aspects play a role, although these connections are not always entirely clear to everyone:

Table 2.2:
(Incomplete) listing of ecological, economic and social impacts of the consumption of animal-based food such as meat

Ecological Aspects	Economic Aspects	Social Aspects
• **greenhouse gas emissions** from **livestock** → amplification of the greenhouse effect → **climate change** • **(inefficient) use of land** in the form of pasture or cropland (e.g. for the cultivation of livestock feed) → **deforestation/destruction of rainforest, desertification** → thereby, among other things, reduced CO_2 uptake → amplification of the greenhouse effect → **climate change** • **(inefficient/high) water consumption** or water wastage • **water pollution** (e.g. by liquid manure from factory farming) • **soil erosion** due to removal of protective vegetation due to overgrazing or deforestation • etc.	• **economic costs** in the form of e.g. high **subsidies** for animal products • **meat exports** from richer countries to poorer countries → **export subsidies** depress meat prices on the world market → **destruction of (local) markets** • growing livestock sector → **competition for land and other resources** → higher **price pressure** on staple foods (e.g. cereals) • increase in natural disasters and droughts → **crop failures** lead to **shortages**, which in turn **increase prices** • less crop caused by decrease of land fertility → **economic challenges for local farmers** • etc.	• high consumption of animal-based foods increases climate change → as a possible consequence: increase in natural disasters, extreme weather such as droughts, fires, floods → **loss of habitats** for humans and animals → "**climate migration**" or "**climate refugees"** (with far-reaching social and economic consequences/challenges) • "**climate migration**" is not only promoted by natural disasters, but also by land degradation caused by improper management of the soil → forcing communities to abandon their homes • unequal food distribution, waste of resources (water, land ...), crop failures due to droughts and increase of natural disasters → impact on **world hunger** • (**diseases** such as cardiovascular diseases, diabetes, high blood pressure, certain cancers, etc.

		intensified by high meat consumption) ● (**antibiotic resistance** due to increased use of drugs in factory farming residues in food) ● etc.

Of course, this list is far from complete, and the effects cannot always be assigned to a single dimension. In addition, the points listed above do not exist alongside each other (as the tabular list might initially suggest), on the contrary, they are interconnected and feedback loops can occur that regulate (dampen) or amplify their effect. The following section outlines some of the points listed above as an interconnected factual description:

The higher the consumption of animal-based food like meat, the higher the greenhouse gas emissions (e.g. methane and carbon dioxide) and thus the greenhouse effect, which intensifies climate change. But climate change is not only exacerbated by higher emissions of greenhouse gases. The increasing consumption of animal-based food also necessitates more land (for grazing and arable land). To meet the demand for land, vast numbers of trees are being felled. This deforestation means that less CO_2 can be absorbed from the air, which also intensifies the greenhouse effect and thus ultimately climate change.
Climate change exacerbates natural disasters and extreme weather events like droughts and fires. The fires in turn intensify climate change, as forests absorb vast amounts of CO_2, which is additionally released by forest fires (self-reinforcing feedback loop).
Natural disasters such as floods or droughts, exacerbated by climate change, result in the loss of homes for many people. Furthermore, crop failures occur due to these extreme weather events, leading to shortages of certain foods. In turn, this causes prices for certain foods to rise. Both factors (food shortages and price increases) contribute to world hunger.

To adequately comprehend this, findings from various disciplines (e.g. social sciences such as geography, economics or natural sciences such as physics, biology, etc.) must be considered in an integrative manner and changes in system elements must be taken into account in context and over time (see 2.1 **Systems thinking**). For this purpose, in the age of globalization and digitization, we have access to vast quantities of information, some of which may be complex, incomplete or even incorrect. The incompleteness can be partly attributed to the fact that certain consequences only occur or become visible over time, i.e. are only partially predictable and thus always entail risks and uncertainties. Critically questioning and evaluating (information) sources, arguments and dealing with them properly contributes significantly to adequately taking into account the complexity of sustainability issues (see 2.2 **Critical thinking**). Finally, in order to respond appropriately to the challenges associated with the consumption of animal-based foods (here: meat), these need to be identified and formulated as a problem in an interdisciplinary manner (see

2.3 **Problem framing**). In our example, therefore, unsustainable consumption (SDG 12, e.g. high consumption of animal-based products such as meat) must first be identified and formulated as a problem in connection with climate development (SDG 13). At the same time, the complexity of the problem (people involved, context and time, etc.) must be taken into account in order to identify possibilities for anticipation, avoidance and adaptation (see Bianchi et al. 2022, p. 22).

On closer inspection, it quickly becomes clear that the competence areas (as well as the individual competencies) do not simply exist alongside one another, but rather as building blocks of a whole in an interdependent relationship (see Bianchi et al. 2022, p. 15). How the individual competencies can be further broken down into knowledge, skills and attitudes can be read in more detail in the document 'GreenComp, the European Competence Framework for Sustainability' (Bianchi et al. 2022, pp. 40 et seq.).

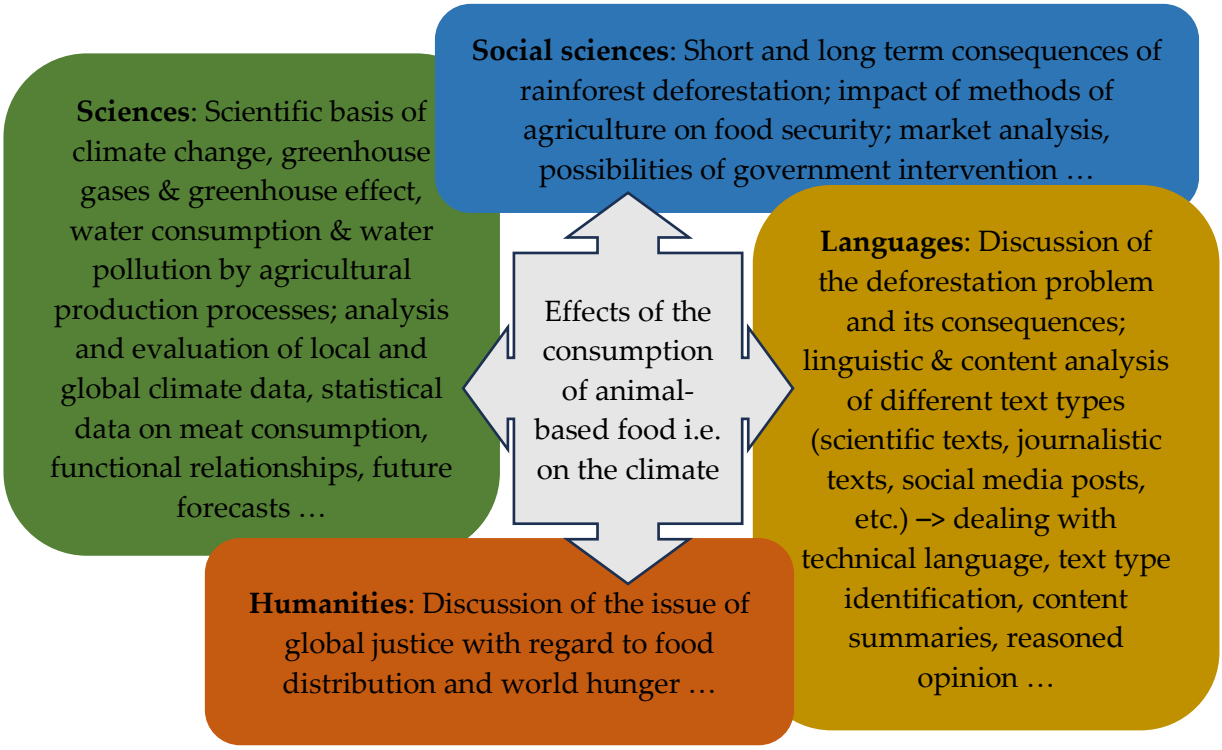
2.3 Interdisciplinarity of Climate Change Education and the Holistic Approach

*The Contribution of Different Disciplines – A **Domain-Specific** & **Cross-Disciplinary** Approach*
Not only among experts, the high complexity of ESD-relevant issues is always emphasized. The example outlined above regarding the effects of meat consumption and animal-based foods on the climate illustrates very well how many (not always predictable) direct and indirect consequences certain behaviors or decisions can have (among other things) from an ecological, economic and social perspective. The many side effects and interconnections cannot be depicted or explained by a single discipline. Although ESD is strongly situated in subjects like geography, this chapter aims to show that all subjects and academic disciplines can and must make a contribution to ESD and thus also to Climate Change Education (CCE). The specific perspective of individual disciplines on ESD-relevant issues is of course necessary and helpful in order, for example, to elaborate on domain-specific features. At the same time, however, a cross-subject treatment of the topic can benefit from synergies. By exemplifying the contributions of various domains/subjects, the interdisciplinary character of ESD and thus also of CCE is to be clarified: Every subject can and should contribute to promoting the necessary transformation processes, because "[c]limate change is a truly interdisciplinary challenge" (UNESCO 2009, p. 2).

Exemplary Contribution of Different Disciplines
When considering the example of the effects of consuming animal-based foods outlined above, it quickly becomes clear that not only an interdisciplinary but also integrated approach is not just expedient but also necessary in order to do justice to the complexity:
Science subjects (such as physics, chemistry, biology) can shed light on the scientific fundamentals of climate change, address the consumption of water in the production of animal-based foods or the pollution of water by agricultural production processes, etc. In chemistry, for example, the carbon cycle and the effects of carbon dioxide and other greenhouse gases on the

greenhouse effect could be addressed. Functional relationships, analysis and evaluation of local and global climate data, statistical data on meat consumption (also in relation to population growth), presentation of resource consumption for the production of animal-based foods such as meat over time including future projections would be just some examples of the contribution of the subject mathematics. In **social science subjects** such as geography, deforestation and its far-reaching consequences for economic and social sustainability could be discussed in connection with the carbon dioxide cycle or greenhouse gases. Macroeconomic costs in the form of subsidies, the question of the destruction of local markets through exports, market analyses and price developments, possibilities for controlling consumption and markets through government intervention could be situated in the subject economics or political education from the same group of subjects. **Language lessons** could address the problem of deforestation and its consequences and discuss them in order to ultimately take a reasoned stance. Among other things, dealing with (current scientific) factual texts or other text types (e.g. journalistic reports and commentaries) can help develop the necessary technical language. The **humanities subjects** such as religion, ethics, philosophy could discuss issues of global justice with regard to food distribution and world hunger in this context (see Fig. 2.2).

Figure 2.2: *Interdisciplinarity and synergies: possibilities of cross-disciplinary treatment of ESD-relevant issues (Source: own illustration)*



The many possibilities of contributions from different disciplines, which partly overlap in content, illustrate the interdisciplinary character of ESD-relevant topics. In order to do justice to the complexity and interdisciplinarity, all school subjects and disciplines must pull together.

The Holistic Approach

Education for Sustainable Development (ESD) – and thus also Climate Change Education (CCE) – should not only play a role as a cross-cutting topic in teaching. Transformative processes can only succeed through a holistic approach, which means that entire institutions must be guided by the principles of sustainability. Thus, the institution 'school' should also become a place of learning for sustainable development (see e.g. UNESCO 2020, p. 28; UNESCO 2016, p. 3; Gehlawat 2016, pp. 54–59; UNESCO 2014, p. 2). As part of ESD, CCE requires an approach that moves away from teacher-centered teaching within one's own subject boundaries towards a holistic engagement, because global challenges require global approaches. 'Holistic' does not only mean presenting and incorporating different perspectives on a problem or topic. This so-called 'Whole Institution Approach' or 'Whole-School Approach' requires – in addition to the transformation of teaching and learning environments – the participation of all actors in the education sector, even beyond school boundaries. In order to represent sustainability in a holistic manner, involved actors must be mobilized. These include:

- "Leaders of learning institutions, including school principals, presidents and rectors of universities and colleges, heads of TVET centres and of staff training centres in private companies.
- Educators, learners, as well as administrative staff in learning institutions.
- Local community leaders, families in the local community, as well as non-governmental and private sector actors working for sustainability.
- Education policy-makers.
- UNESCO and its partners." (UNESCO 2020, p. 28; see also UNESCO 2014, p. 2; Gehlawat 2016, pp. 57 et seq.; European Comission 2022, p. 9).

Figure 2.3: *Whole-School Approaches to Climate Action (UNESCO 2016,p.3)*

It becomes clear that the Whole-School Approach goes much further than implementing ESD in the curriculum because "[s]ustainability is not just something to learn, it's something to live" (European Comission 2022, p. 8). Fortunately, there are a large number of publications that already concretize the implementation of the Whole-School Approach by means of many possible

measures. In the following, some of these measures for implementation will be shown as examples to illustrate the approach described above:

Tabelle 2.3: *Possibilities of implementing the Whole-School Approach ('ESD as school culture') (Source: oriented to: UNESCO 2016, p.7; UNESCO 2014, p.2-3; Lerche et al. 2020; Spahn-Skrotzki 2023, p.70 - 78)*

Field of action/ School Members	**Exemplary measures**
School management/ procurement	● Avoidance of (material) waste or reduction of material consumption (also training of personnel for this purpose) ● Ordering from regional, suppliers who base their work on sustainability criteria (therefore also demand of school directors, parents' representatives etc. to ministries and school boards to make the purchase of products not only dependent on the price) ● Regional, seasonal, fair-trade organic food for the school canteen
Mobility/ Sustainable routes to school	● Promoting environmentally friendly mobility, e.g. through the use of bicycles, public transport, car pooling … ● Therefore encouraging cities and communes to develop suitable infrastructure (good footpaths, cycle paths and bus/train connections)
Waste management	● Reduce, reuse, recycle ● Sorting waste in classes, in teachers' rooms, administration areas …
Teaching	● Sustainability topics such as climate change, sustainable consumption, human rights, etc. as cross-cutting topics in the classroom ● Planning of interdisciplinary ESD projects (for this purpose, joint preparation of a development plan for ESD activities like sustainable school trips, swap meets at schools etc.)
School principals, teachers, administrative staff	● Continuing professional development programs with a focus on (education for) sustainable development ● Participation in decision-making processes ● Introduction of more sustainable office practices, such as double-sided printing and printing only when necessary
Students	● Planning, implementation and evaluation of ESD projects like: Ecological schoolyard design (school gardens, composting systems, nature-oriented schoolyards, etc. with the support of teachers) ● Conducting audits (e.g., waste and energy audits) to measure the school's progress toward sustainability while providing self-efficacy experiences
Employees of the school cafeteria	● Preparation of healthy meals from regional and local ingredients ● Additional offer of vegetarian and vegan meals ● Separation of compostable kitchen waste from non-compostable waste ● Wherever possible, avoiding disposable packaging, plastic ...
Families	● Supporting e.g. climate protection projects of the school ● Conscious consideration of sustainability in everyday life at home

Extracurricular partners	• School cooperates e.g. with retirement homes, youth centers, organic food stores, NGOs etc. to create awareness and further advance ESD • Supporting school projects, e.g. by providing expertise and enabling excursions, etc.

A Whole-School Approach is critical for a variety of reasons, such as …

- addressing the **interdisciplinary nature** of CCE and ESD
- promoting **long-term behavioral change** by living sustainability as a school culture
- **fostering community engagement** that results in a **collective impact** and thereby at the same time **raising further awareness** of sustainability issues
- **encouraging understanding, retention, and linking of knowledge** through repeated exposure to sustainability issues in a variety of contexts. A Whole-School Approach ensures that the message is delivered consistently across subjects, grade levels, and even extracurricular activities.

In conclusion, the holistic approach is crucial for the effective implementation of CCE within the framework of ESD. Addressing complex sustainability challenges such as climate change requires more than addressing the issue across subject areas. It requires the whole school community to live and model sustainability in all aspects of school life. Ultimately, the holistic approach emphasizes that CCESD (Climate Change Education for Sustainable Development) must be transformative. It should equip learners with the competencies to understand complexity, to critically evaluate information, and to envision and implement sustainable solutions. But the authentic implementation of these competencies also requires sustainable school structures and cultures that combine principles with practice. The holistic approach represents a paradigm shift - from compartmentalized knowledge to integrated wisdom, and from individual awareness to collective action. As such, it is an essential component of CCE, which aims to create the systemic changes necessary for a just and sustainable future.

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Chapter 3: Practical Steps to Implement Climate Change Education in Class and Learning Experience Design: Inquiry-based Learning, Gamification and Digital tools

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Abstract: The chapter introduces the main practical steps for implementing appropriate Climate Change Education methodologies in class. More specifically, it explores Learning experience design and describes the ClimaTEPD approach, combining Inquiry-based Learning, Gamification and Digital tools. The presented IBL learning scenarios and practical examples aim to support teachers to successfully transform their classrooms in digitally-enabled playful environments and to actively engage students in real scientific projects.

Introduction

Climate change education (CCE) is still a new concept for secondary school education. This was highlighted on several stages in the review of the State-of-the-Art, prepared within the ClimaTePD project (Intellectual Output /IO1). Studying best practices and CCE implementations across the EU schools demonstrated that many countries still hesitate and look for different alternatives toward CCE integration. Furthermore, it was identified that CCE is hard to be introduced in the subject-dominated school curriculum with traditional methods of learning, as CCE is often organized as an interdisciplinary, project-based, group and STEM-oriented learning activity.

At the same time, active learning methods gain the interest of the teachers and students. However, design and implementation of an active learning scenario can be a very time-demanding task, requiring many hours of preparation, design and coordination work. That is why, the present chapter aims to provide guidance and practical recommendations for teachers how to easily understand, design and implement active learning scenarios, involving digital tools and gamification when designing climate change education active learning scenarios.

The chapter contributes to the overall goal of this handbook, which is to review and synthesises best practices for supporting secondary school teachers in teaching climate change through IBL, gamification, and digital teaching methods in online, face-to-face or blended classroom environments. The chapter is structured as follows. The first section starts with a short overview of the concept of students' learning experience in the context of active learning scenario design. Then, there are explored the basic concepts behind active learning scenario, covering Inquiry-based learning, gamification and digital tools for learning. The second section provides several

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criteria for teachers about how to select the best practices cases and how to approach them in order to implement them in class. At the end are presented several practical implementations.

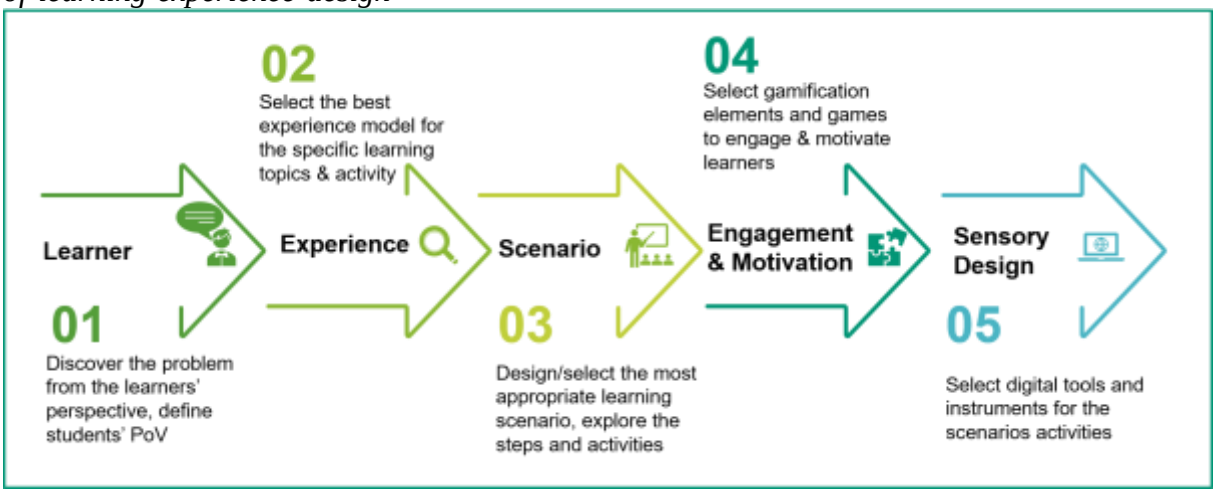
Learning experience design (LXD)

As mentioned above, integrating the climate change education within the subject-oriented school curriculum is challenging for the traditional school system. In many countries, the Climate change topics are dispersed among different subjects and classes, where students partly or incompletely investigate the CCE problems' complexity. Furthermore, traditional learning methods often miss to provide real-life context, oriented toward the students' own situation, learning materials, completing all new discoveries and findings, and challenging alternatives for stimulating high-order thinking perspective. Therefore, most often, teachers need to apply active learning approaches to integrate climate change education in their classrooms.

The concepts of learning experience design (LXD) gains popularity as an integrative approach for active learning. Starting with the learners' needs, the LXD shifts the focus from the instruction to attainment of specific learning goals, to construction of a human experience that is meaningful, engaging, and satisfying (Wilson, 2005). Thus, teachers have to assign learning activities, aligned to students' personal motivations, goals, and values and guide them while constructing meaningful understanding (Chang & Kuwata, 2020). To achieve meaningful, engaging, and satisfying learner' experience, teachers can use in the scenario building model appropriate learning approaches and activities, learning materials, games and digital technologies (Chang & Kuwata, 2020).

Figure 3.1

The model of ClimaTePD LXD, adapted from: https://www.shiftelearning.com/blog/key-elements-of-learning-experience-design



The figure 3.1 presents the main steps for LXD, integrating the main ClimaTePD elements (IBL, Gamification and digital tools):

1. Learner: Explore the problem from the learners' perspective
2. Experience: Select the most appropriate learning approach
3. Scenario: Design/select scenario for defining the learning experience
4. Motivation & Engagement: Assign appropriate digital tools and introduce games and game-based learning elements-
5. Sensory design: Select appropriate digital tools, digital systems, print-outs and others to support scenario activities.

Further readings on LXD from AALTO university: https://www.aalto.fi/en/news/about-learning-experience-design-and-how-creating-learning-experiences-elevates-your-teaching

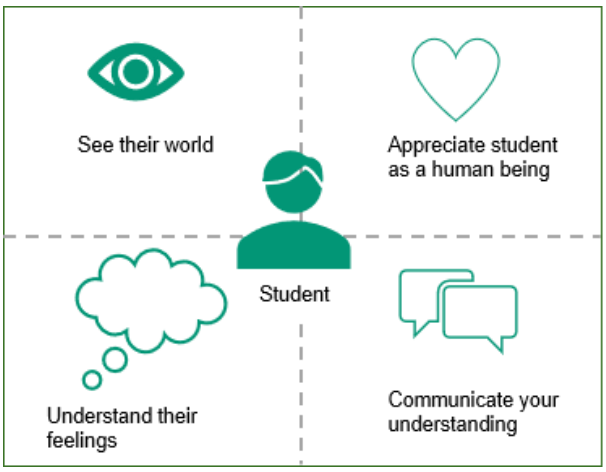
Learner: start with the Students' perspective

The first task of the teacher is to reflect on the students' perspective. How students will understand and perceive the problem in a meaningful way, considering their age, school subjects, personal experience, complexity of the problem, living area, preliminary knowledge, personal interests, hobbies?

To be motivating, the learning experience has to put students in a situation of first-hand exploration, but at the same time, it has to address their own learners' needs, context and real-life situation, preliminary skills and knowledge. By considering all these elements, the teacher will easily understand how to approach the overall experience design. To research and investigate the students' perspective, teachers can explore design-thinking tools and schemes (as fig.2.3), providing a good starting point for defining the student' point-of-view (PoV).

Figure 3.2

Empathyze map



Recommended Resources for design thinking: https://www.interaction-design.org/courses/design-thinking-the-beginner-s-guide

Experience: Select an active learning approach

The learning experience is at the center of the student's-oriented active learning process. Therefore, as next step, the teacher has to select the most appropriate experience-based active learning approach, considering the climate change problem, the context and students' interests and the number of active learning approaches and activities. Active learning methods are based on the constructivist theories of learning (Piaget, 2013), putting the learner in the active position of "learning-by-doing" (Dewey, 1933). After getting direct experience students are involved in reflection and abstraction phase (Kolb, 1994). Experiential learning connects learners with real-life problems by focusing on the process of exploring the problem and collecting and reflecting on data and evidences. Active learning approaches can combine many learning activities, such as inquiry, exploration, gamification, group work, handmade projects, simulations, STEM activities and collaborative projects, outdoor learning, debates and brainstorming sessions, flipped classroom, digital instruments and many others. At the experience design stage, teachers have to consider the general framework for the specific learning experience, taking in considerations:

- *The problem complexity (structured or unstructured and complex problem),*
- *The time for preparation and research (hours or months of implementation)*
- *The outcomes of the experience (preliminary expected or open-ended).*

Teachers can both select and combine several inductive teaching methods such as inquiry-based learning (IBL), problem-based learning (PBL), project-based learning, case-based learning, and discovery (Prince and Felder, 2006).

Figure 3.3
Active learning methods

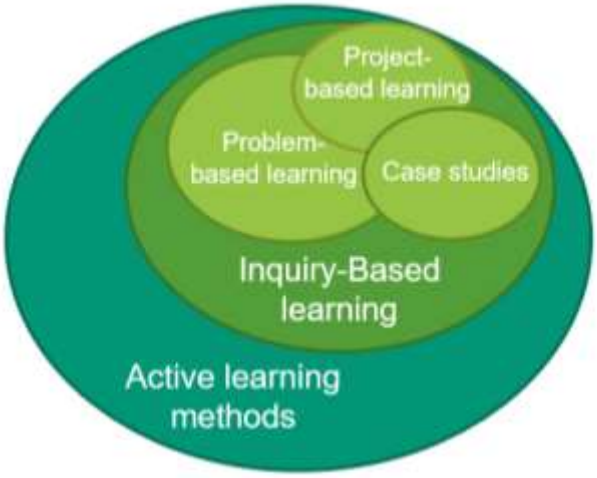
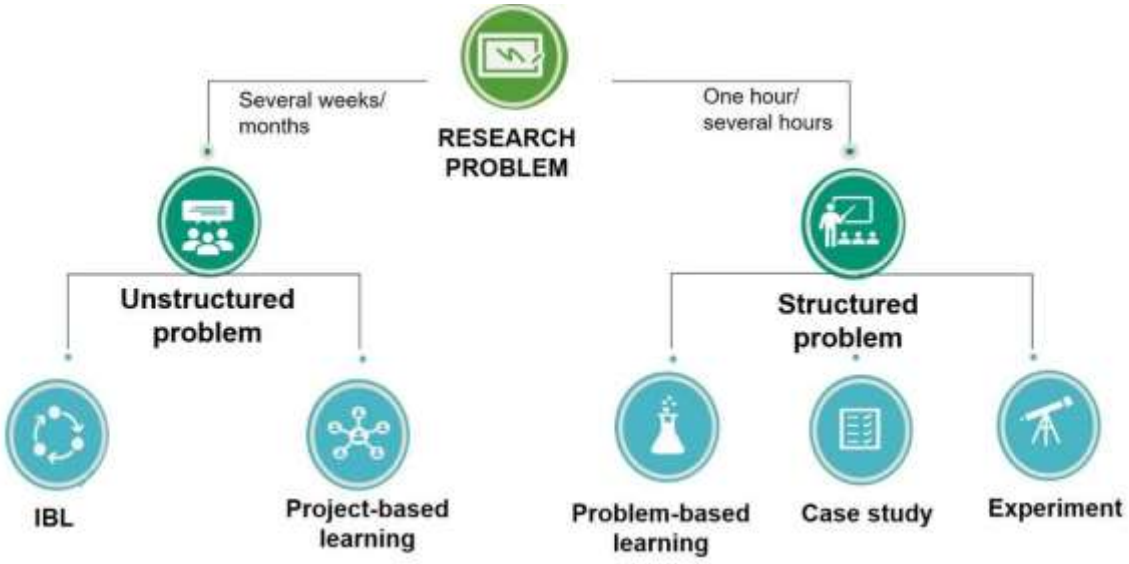


Figure 3.4
Active learning methods and research problems



Inquiry-based learning (IBL)

IBL is among the most popular active-learning approaches, applying scientific method of hypothesis testing, experimenting, results analysis and evaluation. IBL is a learner-oriented approach, based on a structured or semi-structured scenario. The scenario approach makes a

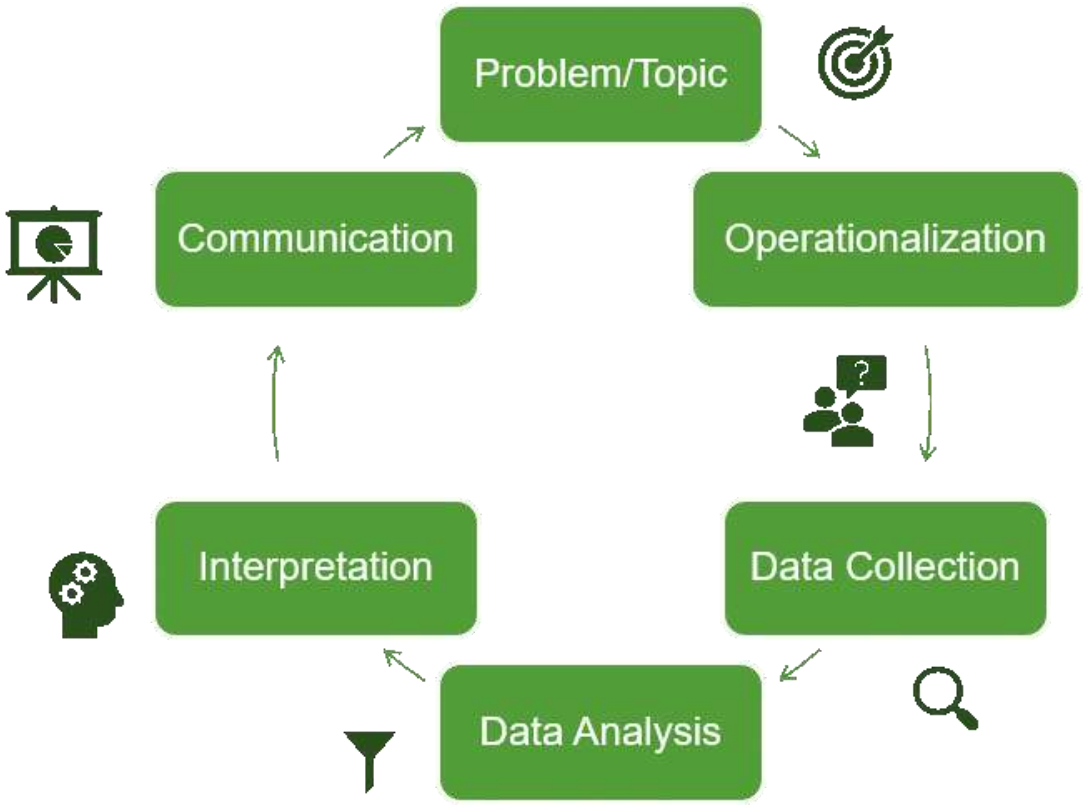
general framework of the inquiry process, selecting main activities, resources, guidance, questions, tools, reflection discussions and insights.

Most importantly, IBL puts students in real-world situations, guiding them to take the leading role in the knowledge discovery and construction process. Students can explore problems and investigate complex situations by asking questions, formulating hypothesis, collecting data, summarizing their findings and presenting the final outcomes. Starting with engaging discussion, the IBL aims to incite students to make suggestions, to explore evidences and to prioritize different criteria, formulating explanations from available evidence, connect explanations to scientific knowledge and theories and finally communicate and explain their findings (Dewey, 1993).

- ***Structured Inquiry.*** Students follow the lead of the teacher, who introduces an essential question and then guides students through specific activities, resources, and assessments.
- ***Controlled Inquiry:*** Students explore one question from several different questions generated by the teacher using a selection of resources curated by the teacher.
- ***Guided Inquiry***: The teacher introduces topics and students begin to formulate their own questions as well as select their own resources to research their answers.
- ***Free Inquiry:*** Students, with the support of their teacher, design their own questions, select their own resources, and customize their own summative assessments to demonstrate what they learned.

Figure 3.5

IBL main six phases



The IBL approach can be suitable to science-related school subjects such as STEM disciplines and to social science subjects (Khalaf et al., 2018). The IBL methods require both teacher and students to actively engage and immerse in the Inquiry process. That is why, the topic should be both motivating and interesting for the students and has to be presented in an appealing way. The

reflection after each IBL phase is very important and teachers have to prepare enough time for engaging in thought-provoking discussion.

Among the key questions, teachers have to support students to discover alone:
- What is the research problem?
- Why this problem is relevant?
- How to investigate this problem?
- How to collect data?
- How to analyze the data?
- How to interpret the outcomes?
- How to present the result?

Recommended Resources for IBL:

Handbook with guidelines for STEM teachers' inquiry and reflective practice

https://www.learning-in-teaching.eu/images/docs/EN/O6_final_report.pdf

Key messages and Guidelines for IBL training: https://www.learning-in-teaching.eu/images/docs/EN/3_O6_KeyMessages_EN.pdf

Scenario building – Design Learning Experience scenario

The best way to make a learning experience design, is to break the learning process on several sub-stages or phases. This way, the teacher can precisely plan and align all relevant activities, materials and digital tools to every phase of the learning process. More specifically, teacher can identify the most difficult and challenging phases, and put additional efforts to support students with additional guidance, materials and games.

This way, the learning experience design can provide a good understanding about the students' feelings and experiences. Teachers can plan accordingly personalization and individualization strategies, exploring different learning activities, learning materials, gamification models and digital tools.

Table 3.1

General LXD scenario for active learning

Learning experience design	**Phase 1 – Introduction**	**Phase 2 - Planning**	**Phase 3 – Implementation**	**Phase 4 Presentation**
Main question	**Why?**	**How?**	**What?**	**So, what?**
Time-frame	1 hour	1 hour	6 hours	2 hours
Phase goals (Example)	Engage & motivate students	Plan the process	Perform the activities	Presentation Reflection Self-assessment

Activities (Example)	Investigate, Brainstorm, Put-in-the other's shoes	Explore procedures, methodologies, algorithms	Individual/Group work to collect and analyze data and observations	Presentation, Debriefing, Self-assessment
Learning materials (Example)	Video, Story-telling, media post (article)	Hand-out, To-Do lists	Hand-out	Hand-out, Self-assessment form
Digital tools (Example)	Video, media site, search engine	Digital planners, digital maps, search engines…	Metering device, data analysis tools	Digital editors: presentation, video, comics, etc. social media
Student' feelings (Example)	Level of engagement Level of interest Motivation in the topic	Level of understanding and engagement with the process	Feeling of belonging, contribution to the process, achievement	Satisfaction, Achievement, Meaningful outcome
Challenges of the phase (Example)	Students' miss the importance, not interested in the problem, lack of confidence	Lack of patience - hurry-up to the main point, lack of understanding the "big picture"	Students not involved in the process, Lack of materials, time, tools…	Lack of understanding the "big picture"
Gamification and engagement elements (Example)	Role-play, Dream-about (what-if), Treasury hunt (find all relevant issues), Escape room	Simulation, Exploration of real-world tools and methods (in specific professions)	Collaboration, team-work games, time management strategies	Competitions and Contests, involve external public, Public exposition of the results, feedback from stakeholders

IBL scenario building process

Applying scenario building in the Inquiry-based learning process can be illustrated as follows. It can integrate up to six phases of the structured inquiry. At each phase, students, working individually or in groups, can develop their own questions to examine and engage in self-directed or instructor-led inquiry. The phases can include diagnosing problems, formulating hypotheses, identifying variables, collecting data, documenting their work, interpreting and communicating results (Chaimala & Kikis-Papadakis, 2019).

Table 3.2

Implementing the LXD on IBL main phases.

IBL PROCESS	Problem	Operationalization	Data Collection	Data Analysis	Interpretation	Communication
Learning Activities	WoW moment Define problem Discussion	How to… Group work Methods/Tools	Collecting data… Surveys/interviews /search	Data Analysis/ Statistics/ Scenarios/ Relationships	Hypothesis testing	How to present the result? Creativity/Design tasks
Learning Materials	Pptx Video/Game	Handout/Pptx/ Tutorial	Handouts/ Data bases	Handouts/ Presentation	Handouts/ Presentation	Handouts
Digital tools	**Video/PPTx Interactive videos/Games/ Mindmaps**	**Digital Metering Search engine**	**Data bases/ Digital Maps Internet sites Survey tools**	**Spreadsheets/ Statistic Calculators/ Graphics/Tools Mindmaps**	**Spreadsheets/ Statistic Calculators/ Graphics/Tools Mindmaps**	**Videos/ PPTx/Movies/ Web-Site/ Infographics/ Comics/Publisher/Digital books…**
Student Experience						
PAIN POINTS	How to gain interest	Loosing interest in tools/methods to investigate…	Feel lost in data available Critically assess data sources	Feel lost in data analysis/ Lack of skills/understanding how/ why…	Feel lost in data analysis/ Lack of skills/understanding how/ why…	Feel lost in data analysis/ Lack of skills/understanding how/ why…
Games and Gamification	Engaging students	First hand experiences on Draw/Map/Discover	Competition/ Exploration	Tools mastery	Gain context of the research	Competition/ Exploration

Engagement and Motivation - Gamification

Gamification techniques aims to increase engagement and motivation of the students with the use of games or game-based approaches. Gamification techniques can make learners more relaxed and engaged in the learning, while working in cooperation or in competition with the other students. Having its roots back to the sixties when Piaget underlined that games could not only help children to master their environments but also to create the worlds of their imagination, gamification could engage learners in promoting active, experiential and problem-based learning (Majuria et al., 2018). With the development of technologies and the integration of ICT in education, gamification has been applied in different disciplines in all the educational levels, increasing the learners' motivation in activities and fun (Swacha, 2021). Teachers can use gamification strategies in their LXD to increase students' satisfaction, engagement, effectiveness and efficiency (Paniagua & Istance, 2018). Gamification and engagement models cover the pedagogical core of gaming and the benefits of playful environments for students' engagement and well-being. There are two main pedagogical components: mechanical elements (rapid feedback, badges and goals, participation, and progressive challenge) and emotional elements (narratives and identities, collaboration and competition).

To engage and motivate students in the LXD process, teachers can select gamification elements in every step of the scenario. This way, they can support students to better engage and improve: understanding of the problem, the simulation of the situation, decision-making, social skills, socialization and cooperative work, engagement, concentration and autonomy.

Table 3.3
Examples of Gamification elements

Gamification - example	Digital tools	Socialization factors	Fun factors	Recognition factors
Role-play, Drama, Story-telling	In presence or digital: Video, Comics, Infographic	Collaboration, group work	Imagination, creativity, reality exploration, fun elements	Public applauses, Positive Feedback
In-class contests and competitions such as quizzes, Q&A, and others	Kahoot! Mentimeter Google forms	Individual competition	Funny Questions Time factor (Tension) Funny Rewards	Mastery achievement points/badges
Public Debates, Structured discussions	Kialo.edu	Group competition	Tension, Chance Funny Rewards	The best team award
DIY, Hands-on activities, Modeling, drawing, creating	Hands-outs, Editors	Team work	DiY, creativity, imagination; mastery; ability; exploration	Public exhibition, Open gallery, Award ceremony
Simulation Games	Video-games, video-simulations	Competition and collaboration	Chance factors, Exploration, Time factor (tension)	Individual/Group achievement
Brainstorming and mind-map activities	Brainstorming and mind-map tools	Collaboration	Creativity, out-of-the box thinking, reality exploration,	Group achievement
Treasury hunt (searching and arranging elements)	Video-games, Escape room, Hands-out	Competition/ collaboration (group)	Find elements, explore their meaning, imagination	Individual/Group achievement

Sensory Design - Digital tools and digitalization

The sensory design within the LXD scenario aims to introduce the concepts of physical interaction and visual design. All learning materials, used for scenario implementation should be prepared accordingly to the students' age, skills and goals of the learning activities. For physical learning materials, consider individual and group tasks: ensure appropriate hand-outs, print-outs and textbooks, DIY materials, office stationary tools and others. Consider physical arrangement in the classroom when organizing active learning scenarios such as group/team work, role-play, debates and others.

When using digital tools and instruments, consider how and where students will work with them – in a computer classroom, on their smart phones (are there specific school rules for BYOD), as homework or as out-of-the class activity (in library or other).

Using digital tools and instruments, as well as digital games and videos can be engaging and motivating only when they add value to the learning process. Consider how students can effectively engage with digital tools and ICT resources in the classroom, do they have experience with the selected ICT resources, are they accessible and easy to learn? The table below presents some popular digital tools, that can be used in the LXD scenario.

Table 3.4

Examples and Selection of Digital tools and instruments

	Tools functions	Examples
Collaborative tools	White boards and virtual collaboration tools	Google Jamboard - https://jamboard.google.com/ Storm board - https://stormboard.com Miro - https://miro.com Padlet - https://padlet.com/
	Digital tools for debates, argumentation, critical thinking	Kialo-edu - https://www.kialo-edu.com/ Mentimeter - https://www.mentimeter.com/
	Digital mind-maps, collection for ideas for hands-on activities and experiments	Cooggle - https://coggle.it Mindomo - https://www.mindomo.com/ FreeMind - http://freemind.sourceforge.net/wiki/index.php/Main_Page FreePlane - https://www.freeplane.org/wiki/index.php/Home
Interactive tools	Digital tools for 3D Modelling	**Thinkercad** - https://www.tinkercad.com/ **Sketchup** - https://www.sketchup.com Other 3D modelling software
	Digital tools for online games	Learning Aps - https://learningapps.org/ Kahoot! - https://kahoot.com Quizlet - https://quizlet.com Jeopardy - https://jeopardylabs.com Educaplay - https://www.educaplay.com/types-of-activities/ Socrative - https://www.socrative.com
Tools for visualization	Videos/ Storytelling Geographic maps	ARCGIS – https://storymaps.arcgis.com/ https://teach-with-gis-learngis.hub.arcgis.com/ Google maps - https://maps.google.com Google Earth https://earth.google.com
	Digital tools for photo /picture editing	**Digital tools for photo /picture editing** MS Paint, GIMP, Adobe Photoshop Express
	Digital tools for presentations, posters, printed materials	**Digital tools for presentations, posters, printed materials** MS PPTX, Prezi.com MS SWAY, MS PUBLISHER, CANVA, PICKTOCHART

	Digital tools for storytelling, Digital comics, video stories, books	**Digital tools for Comics** • https://www.storyjumper.com/main/classroom • https://www.storyboardthat.com/ • https://makebeliefscomix.com • https://www.pixton.com **Digital tools for Video stories** • https://videomaker.simpleshow.com • https://www.adobe.com/education/express/ • https://new.edmodo.com/ **Digital tools for Digital books** • https://bookcreator.com/ • https://www.storyjumper.com/ • https://genial.ly/create/gamifications
Climate change tools	Digital tools and calculators	**Digital tools and calculators for climate change** • https://www.fs.usda.gov/ccrc/tools • https://interactive-atlas.ipcc.ch/ **Online foodprint calculators** • https://www.earthday.org/foodprints-calculators/ **School CC footprint** • https://depts.washington.edu/i2sea/iscfc/index.php • https://depts.washington.edu/i2sea/iscfc/calculate.php **Climate change visuals** • https://climatevisuals.org **Open data for climate change** • https://climate.esa.int • https://climate.nasa.gov

Criteria and sources to select best practices

Based on the theoretical and conceptual work developed in ClimaTePD IOs 1 to 5, the following criteria were determined to select best practices to implement Climate Change Education in class based on Inquiry-based learning, Gamification and/or digital tools:

1. The practice is concerned with increasing students' awareness of one or more climate education concerns
2. The practice includes inquiry-based learning and at least gamification or digital tools
3. The practice includes sufficient level of detail to be replicated by another teacher or education practitioner: objectives, development, learning resources and assessment plan
4. The practice has been tested with real students in a classroom setting

In order to find best practices for climate change education with IBL, gamification and digital tools the following sources of information were reviewed:

- Experiences with the ClimaTePD professional development course, as reported in the transnational report on online training and teachers' reflections (IO5.2)

- Experiences that teachers participating in the ClimaTePD project activities have shared or reported
- Online repositories – ClimaTePD repository
- Academic articles;

Good Practice Examples

This section presents a selection of best practices to implement Climate Change Education in class based on Inquiry-Based Learning, Gamification and/or digital tools.

Example 1

This good practice is a learning scenario that integrates IBL, gamification and digital tools. The scenario is called "The drought that unites us" and it was designed by Ms. Maria Martinez from Spain during her participation in the ClimaTePD professional development. The scenarios is motivated by the fact that Spain has been suffering a drought for a long time and that it affects many different parts of the country. It is aimed for the two last years of compulsory secondary education, this is, students between 15 and 16 years old. It is motivated by the presence of this environmental problem in the news and the impact in student's lives, for example with restrictions in the water usage in their village. Many of these students belong to families that work on the primary sector (agriculture and cattle), so they can see how their families are worried that the drought and the subsequent restrictions may affect their businesses.

The scenario follows a guided approach to IBL, with 6 phases: 1) Ask questions, 2) Presentation of the topic, 3) Guided data collection, 4) Data analysis and results, 5) Interpretation, and 6) Communication. The scenario is planned to last between 6 and 8 hours.

Gamification is used mostly in the first phase, with the aim to engage students in learning and test their starting knowledge. More specifically, students play games in small groups under the supervision of the teacher. Some of these games are physical (see figure 6 below) and others are digital (see figure 7 below).

Figure 3.6
Screenshot of one of the digital games included in this scenario: "Meteorological phenomena", by Pablo Diaz Vera

Figure 3.7
Screenshot of one of the digital games included in this scenario: "Effects of Climate change", by Escuela Número 31

The scenario makes use of several digital tools for different purposes. For example: Google Classroom for the teacher to provide information resources, mainly webpages; Data analysis tools to make graphs; Digital walls to share the results such as Padlet or Canva; tools to make comics such as pixton.com; or video editors such as Clipchamp.

Example 2

This good practice example is the learning scenario "Concrete factories: what dangers to they entail?" that the teachers Javier Beltrán Ayllón and Eva Casas Güell from Spain designed in a collaborative way as part of the ClimaTePD course. The scenario addresses CCEd with a strong IBL methodology and a productive use of digital tools.

The scenario starts from the local context, by focussing on the concrete making factories that are located around many schools in the area. Students develop an inquiry that aims to helping them understand the connection between this local activity and the global problem of climate change. The scenario is aimed at all levels of secondary school with adaptations from the teachers, and can be completed between 10 and 12 teaching hours.

The scenario starts with a news clip from the regional television where the neighbours of a town are against burning waste in their premises. At this point, the objective of the scenario is established, i.e. to make a video that presents the results of an inquiry about the effects of concrete making factories in people's health. During a week, in small groups, students collect information and store it. Then, they make a report and sketch proposals to improve the situation following the problem-solution model that was presented in the ClimaTePD course. Finally, students make the video and reflect about what they have learnt.

The main digital tools that are used in this scenario are cloud-based text documents so that all students from a group can access, digital walls such as Padlet to share results with other groups, and a tool to make videos based on text and without need to record any footage called Powtoon.

Example 3

This good practice is a learning scenario called "Urban green spaces", which presents a productive integration between IBL and gamification, supported by digital tools. The scenario was developed by Mr. Jaume Benet i Beltran as part of his participation in the ClimaTePD course. The scenario guides students in discovering urban ecosystems that can be found in the surroundings of the school and their importance to make the city more sustainable. It is designed for the first years of compulsory secondary education, this is, students between 11 and 12 years old. It corresponds to the subject of biology, which at this educational level it is taught as part of a course called "Natural sciences".

The scenario follows the guided inquiry model, with the 6 phases. After the problem definition phase, students prepare to study one of the urban ecosystems that can be found in the city in order to determine their sustainability. To that goal, they determine sustainability criteria and they become familiar with the concept of "Dichotomic key" using a digital version of the game "Who is who".

Figure 3.8

Example of the dichotomic keys (learning resource) that is included in this scenario

After that, students move on to collect data in an activity where they have to take photos and identify the maximum number of plants in a specific area (gamification). Students make an interactive map that includes the photos the took with ArcGIS, and they collect ideas on how to make the space more sustainable. Finally, each group makes an infographic that lists the green spaces in the city, its benefits, how to improve them, and a QR code to the interactive map that they created. The scenario finalizes with a presentation to the other groups and peer assessment.

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Chapter 4: Teachers' Community Building Skills: Bringing Together Stakeholders for Climate Change Education

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Abstract: The present chapter explores how Climate change projects in schools can incentivize active participation from students, parents, and the local community. It emphasizes on the primary role of teachers in improving science communication, nurturing students' interest in the research process and fostering their natural curiosity. Therefore, the present chapter aims to uncover the essential skillsets and competencies teachers should raise for effective community building and science communication.
The chapter starts with a short introduction to fundamental terms, followed by a discussion of the community-building process, offering practical advice and real-life examples. Then, it delves into various science communication approaches, presenting teachers with diverse best practices. The chapter ends with several examples of how teachers can empower positive change within their communities while fostering a passion for science and research among their students.

Introduction

Schools play a central role for the local communities' life (UNESCO). Especially in the field of Climate Change Education, teachers and students cannot work in isolation from the local problems. On one hand, students should recognize what are the local challenges related to climate issues, and on the other hand – to understand how local communities already work on them and how they can be involved. Therefore, by inviting experts, local stakeholders and parents, teachers can make the ClimaTePD scenarios more relevant and engaging for students. Even more, students can contribute to community projects, studying local real-life climate issues, providing data and evidences, raising awareness, investigating innovative solutions to specific problems or making connections with more considerable projects. Many examples are already provided in the literature (Sobel, 2004), and many practical case studies can serve as inspiration for teachers and schools.

All this comes to show that teachers need to possess community building skills to organize and involve local stakeholders in the complex learning experiences. On one hand, teachers should be prepared to collaborate on Climate change issues with external experts and stakeholders, such as researchers, experts from NGOs, local businesses, parents and others. On the other hand, teachers should know what is citizen science and open science movement and how to recognize opportunities to cooperate and take part in school networks or in joint projects with teachers from other classes or schools.
The present chapter explores how teachers can schedule and plan various activities and events to promote community building events such as: monthly teachers' and experts' gatherings for demonstrating and discussing good practices, involving community stakeholders in student's

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projects, as jury in science expos and science fairs, organise students' competitions and study visits, take part in public events organised in local research and university centres, museums and libraries, (f.ex. citizen science), make visits to open labs and research infrastructure, explore further training opportunities for students and staff. ClimaTePD aims to encourage teachers to raise awareness and collaborate with local stakeholders on multiple perspectives.

Secondary School Teachers' Roles

The abilities to work actively with the local community and to act as effective science communicators should be part of the teachers' professional mindset. This is even more important when considering the topics of the climate change education. Evaluating to what extent teachers are prepared to do so, can suggest further how schools can support them in more practical terms. To that goal, these specific competences have to be described, as for example, per the specifications in European legislation, policies, and teacher education frameworks. Further, existing professional profiles that share the principles of building a scientific community are reviewed, including science communication, citizen science, and others.

Teachers Competences and Skills

Teaching competences describe the performance that is expected from teaching practice, as a way to describe behavior: "Complex combinations of knowledge, skills, understanding, values, attitudes and desire, leading to effective action in situation in a particular domain" (Deakin Crick, 2008, quoted in Caena, 2014). There is no specific framework for secondary school science teaching competences at a European level, as opposed to other areas such as digital competence (Redecker & Punie, 2017). The only competences highlighted as important in general teacher competence frameworks are: "a specialist knowledge of the subject(s) they teach, plus the necessary pedagogical skills to teach them, including teaching to heterogeneous classes, making effective use of ICT, and helping pupils to acquire transversal competences" (European Commission, 2013).

A distinction has been made between teaching competences and teacher competences (Caena, 2011), also in EC (2013) & OECD (2009). Whereas the first describes those needed to facilitate student learning, the second follows a systemic view of the teaching profession, which takes into account other dimensions outside classroom practice such as the school and the community (Martínez-Izaguirre, Álvarez de Eulate, & Villardón-Gallego, 2017). The second view is useful to understand what can be described as the "teachers' ecosystem", as it involves other people and contexts than what happens in the classroom. By looking at existing competence frameworks it is possible to see that quality STEM education includes an integration with the context, this is, participation in activities that take place outside of the classroom or the school. As an example, the STEM education framework from the New York Academy of sciences states real-world application as part of the key aspects for instructional design of STEM education, understood as

making explicit relations between scientific content and problems or challenges that students may have to deal with outside of school.

Teacher Perspective for Community Building

In more general perspective, community building skills refers to a set of abilities, competences and qualities that individuals need to possess to foster a sense of belonging, trust, and collaboration within the local community. As a term "community building" or "community development" is often referred to political movement, emphasizing on the role of the communities for social development and social actions and in general enhancing democratic participation, education and empowerment for coping with social problems (Gilchrist & Taylor, 2016). In table 1 are defined some of the essential community building processes.

Table 4.1

Essential Community building processes, based on (Gilchrist & Taylor, 2016)

Community Building Processes	Description
Enabling	Set up opportunities for people to be involved in the community work, remove barriers for their participation
Encouraging	Facilitate individuals to contribute to activities and to participate in decision-making.
Empowering	Strengthen confidence and ability to work together, take responsibility and create conditions to make substantial change.
Engaging	Improve community participation and involvement in various forms of decision-making
Educating	Improve knowledge sharing, reflection based on the experience and discussions.
Equalizing	Ensure everyone has equivalent access to opportunities, resources and facilities
Evaluating	Identify positive changes, lessons learned and key factors

To successfully involve local stakeholders in climate change educational projects, schools and teachers should better understand these key elements in the community building skillsets. Community building is a long-standing process, requiring substantial efforts to connect with others, build trust, and create an environment where people feel empowered to collaborate and contribute positively to the community sustainability and well-being.

Figure 4.1
Community Building Skillset, developed on the framework of Winkler & Zimmermann (2015)

The community-building process should start with defining **a common cause** that needs to be recognized by all relevant community members and stakeholders. To grow long-lasting relationships, schools and teachers should establish a common cause, serving as community vision, unifying framework and platform for further cooperation. The other community-building skills: communication, cooperation and empowerment will be explored in the sections below.

Communication Skills

Communication skills aims to build common understanding, to set up shared goals and to improve planning of activities among community members. Communication skills cover the ability for establishing good interpersonal relationships, including skills for active listening, ability to express ideas clearly and to engage in constructive conversations. Empathy and understanding of the needs, feelings, and perspectives of the others foster a sense of compassion and support within the community. To make a good communication framework, teachers and schools need to establish effective communication strategies, such as:

- **Set up appropriate communication channels** to engage with the stakeholders. These can be regular meetings, emails, phone calls, social media platforms, or physical newsletters.

- **Initiate contacts with potential stakeholders and build positive relationships with them**. Teachers can attend community events, introduce his or her educational objectives, and express interest in involvement in community activities.
- **Clearly explain how different stakeholders** can contribute and make a difference in the lives of students and the local community.

How teachers and schools can **communicate effectively** the goals of Climate Change Education and ClimaTEPD student projects?

1. ***Community Outreach:*** Reach out to local community organizations, environmental groups, and government agencies involved in climate change initiatives. Invite them to school events or presentations where students can showcase their projects and discuss their findings.
2. ***Partner with Local Media:*** Contact local newspapers, radio stations, or television channels to cover the students' climate change projects. Media coverage can help raise awareness about the issue and attract attention from the broader community.
3. ***Utilize Social Media:*** Leverage social media platforms to share information about the students' projects and reach a broader audience. Engage with the community by using hashtags, posting updates, and encouraging discussions.
4. ***Develop Educational Materials:*** Create educational materials based on the students' projects, such as brochures, posters, or infographics. Distribute these materials to the community to raise awareness about climate change issues.

Collaboration Skills

Teachers and schools have to involve local community stakeholders in joint activities and collaboration tasks. Encouraging collaboration and teamwork among community members promotes a sense of camaraderie and collective ownership of community projects and initiatives.
Considering collaboration skills, teachers need to pay attention on:

- Leadership skills, as effective community builders should inspire and motivate others, encourage participation, and help guide the community towards its goals.
- Networking skills, recognizing that building and maintaining relationships with various stakeholders and external partners can help a community to access additional resources, support, and expertise.
- Event Planning and Facilitation: Organizing events and activities that bring community members together strengthens their bonds and provides opportunities for meaningful interactions.
- Conflict Resolution, as conflicts are inevitable in any community. Thus, teachers should be skilled at resolving them peacefully and fairly is crucial for maintaining a harmonious atmosphere. Conflict resolution skills may help to address issues constructively and prevent long-term divisions.

To plan and organize various collaboration activities for community members, teachers and schools can involve stakeholders in some of the following:

- **Invite stakeholders to provide input:** let stakeholders have multiple opportunities to provide input and feedback on the educational initiatives. Conduct surveys, focus groups, or individual interviews to gather valuable insights.
- **Collaborate on project design** and involve key stakeholders in the planning and design of the educational projects. Their input can lead to more relevant and impactful topics, activities and initiatives for the students that will make real impact and will address community needs.
- **Share Success Stories and Progress:** Regularly update stakeholders on the progress of the project and share success stories of how their involvement has made a difference. This fosters a sense of ownership and pride in the community's contributions.
- **Recognize and Appreciate Contributions:** Acknowledge the efforts and contributions of key stakeholders through public recognition, thank-you notes, or appreciation events. This reinforces their commitment and encourages ongoing support.
- **Provide Resources and Support:** Ensure that stakeholders have the necessary resources and support to participate effectively. This may include providing training, materials, or access to relevant information.

How teachers and schools can set up **community collaboration activities** in the framework Climate Change Education and ClimaTEPD student projects?

1. ***Collaborate with Local Experts:*** Invite environmental experts, scientists, or activists from the community to speak to students about climate change topics. Their insights and experiences can provide valuable context and inspiration for the projects.
2. ***Conduct Surveys or Petitions***: Encourage students to create surveys or petitions related to climate change topics and gather signatures or feedback from the local community. Share the results with the community to demonstrate the significance of the projects.
3. ***Host Community Workshops or Webinars:*** Organize workshops or webinars related to climate change topics, led by students or guest speakers. Invite community members to participate and learn more about the issue.
4. ***Organize Tree Planting or Clean-up Events:*** Plan environmental activities, such as tree planting or community clean-up events, that involve both students and community members. These practical actions can strengthen the sense of community involvement and environmental stewardship.
5. ***Engage Local Leaders:*** Invite local political leaders or policymakers to attend student presentations or events. Their presence can signal the importance of the projects and encourage community participation.

Empowerment Skills

Empowerment skills aim to incentivize local community members in various activities, projects and endeavors in a way to create a lasting impact. Thus, on the first place, problem-solving skills explain how teachers can prepare to address challenges and to find creative solutions. This way, they could overcome obstacles and more easily achieve collective goals.

Empowerment include as well patience and persistence, as building a strong community takes time and efforts. Teachers and schools need to be patient and persistent in the face of setbacks or slow progress. Furthermore, they need to ensure that they can successfully improve:

- **Appreciation and Recognition**: Acknowledging and celebrating the contributions of community members fosters a sense of value and encourages continued engagement.
- **Evaluate and Share Results**: Regularly evaluate the outcomes of the educational initiatives and share the results with stakeholders. Transparent reporting helps build trust and demonstrates the value of their involvement.

How teachers and schools can improve **empowerment of the local communities** in the framework Climate Change Education and ClimaTEPD student projects?

- ***Host a Community Fair:*** Organize a climate change-themed fair or exhibition where students can present their projects. Invite parents, community members, and local organizations to attend and engage with the students' work.
- ***Adopt Sustainable Practices in School:*** Lead by example by implementing sustainable practices within the school, such as recycling programs, energy conservation initiatives, or eco-friendly landscaping. Involve students in these efforts and invite the community to participate as well.
- ***Seek Sponsorship or Donations:*** Approach local businesses or organizations that align with the cause of climate change awareness. Ask for sponsorship or donations to support the students' projects and events.
- ***Facilitate Collaboration Between Stakeholders:*** Encourage collaboration between different stakeholders to maximize the impact of the project. For example, schools can partner with local businesses for mentorship programs or community organizations for workshops.

Teacher Perspective as Science Communicator

In order to build a local community, supporting climate change education, teachers can obtain inspiration from different examples of community building between scientists and the rest of society. The integration between science and the rest of society has been a matter of discussion for decades now, since the effects of scientific and technological developments started to become

visible. Most authors find the origin of this discussion in the late 50s, when launching the Sputnik satellite threatened the position of the US as a world leader and there was a need to "explain" to citizens the processes and products of scientific and technological progress (Kozyreva & Wineburg, 2022; Mansour, 2009). Since then, the integration between science and society has taken several forms, which can be summarised in ***science outreach and science integration***. The "science outreach" approach comprises policies that describe different levels of citizen involvement in R&I. The first level can be described as "communication of results", which responds to the view of citizens as contributors. If research is funded by tax, contributors should know how that money is used (de Saille, 2015). The second level of citizen engagement in science is based on a two-sided communication between scientists and citizens. For instance, the EU promoted a greater engagement of stakeholders such as patient groups in health research, or companies, in a deeper way, i.e. not only as "receivers" of R&I activities but as participants in a process of dialogue (Rodríguez et al., 2013). On the other hand, the "science integration" approach perceives science and society at an equal level. In this scope, scientists (through the institutions where they develop their activity) and the rest of society collaborate in R&I (Apotheker et al., 2017). This is the approach that is predominant in Europe since a few decades, and it has been called Responsible Research and Innovation, or RRI (de Saille, 2015; European Commission. Directorate-General for Research and Innovation, 2015; Gorghiu, Dumitrescu, & Petrescu, 2016; Grunwald, 2011; Owen, 2014). As part of this overarching policy, citizen science has arisen. Citizen science can be defined as the development of scientific activity with the participation of those who do not devote their professional activity to science (Trisha Gura, 2013). The implication for secondary school teachers who wish to address climate issues is that they have an opportunity to contextualise the learning activities in real, ongoing scientific projects. This should promote student engagement and motivation. Some general terms are defined in Table 2.

Table 4.2

Common Definitions of the terms: Citizen Science, Open Science and Community-Led Science

Term	Explanation
Citizen Science	A collaborative approach to scientific research in which general public can actively participate in scientific data collection, analysis, and in the formulation of research questions. The citizen scientists can contribute with their observations, data, or expertise on ongoing scientific projects, expanding the scale and scope of research endeavours. Citizen science projects encompass a wide range of disciplines. Usually volunteers, citizen scientists can act as data collectors, data processors, or project collaborators. The engagement of citizens in scientific endeavours not only enhances data collection but also fosters public understanding and appreciation of science.
Open Science	Open science aims to make scientific research and data openly accessible to the public, without restrictions or barriers. It involves sharing research

Term	Explanation
	findings, data, methodologies, and other research outputs freely and transparently. Open science aims to promote collaboration, reproducibility, and accountability in research while fostering innovation and accelerating scientific progress. By making research outputs openly available, other scientists, researchers, and the public can verify, build upon, or use the findings for various purposes, ultimately enhancing the overall impact and utility of scientific knowledge.
Community-led Science	Community-led science refers to scientific research or projects that are initiated, designed, and driven by local communities or groups of individuals with a shared interest in addressing specific issues or challenges. In these initiatives, community members actively participate in defining research objectives, data collection methods, and decision-making processes. The emphasis is on collaborative and inclusive approaches, where scientists and researchers work alongside community members, respecting local knowledge and perspectives. Community-led science aims to empower communities to address their unique concerns, utilize their expertise, and create solutions that are contextually relevant and sustainable.

Involving students and local community to citizen science projects

Involving students and the local community in citizen science projects can be a powerful way to promote scientific understanding, community engagement, and environmental stewardship. Opening up the students' projects and inviting members from the local community to contribute to the can additionally engage students and make the learning process more effective and efficient. There can be revealed several effective strategies for teachers to involve the local community in citizen science initiatives.

Some practical advices for setting up a climate change project can be:

Set up Common cause

- **Identify Relevant Climate Change Projects:** Choose citizen science projects in the field of Climate Change that align with the interests and concerns of the local community. Projects that relate to local ecosystems, wildlife, pollution, or climate can be particularly engaging.

Communication:

- **Involve and communicate with Local Experts:** Partner with local scientists, researchers, or environmental organizations who can provide guidance and expertise in designing and conducting citizen science projects.

- **Community Outreach:** Engage in community outreach by attending local events, fairs, or meetings to promote the citizen science projects. Distribute informational materials and encourage participation.
- **Host Information Sessions:** Organize information sessions or workshops to introduce the concept of citizen science to the local community. Explain how participation can make a difference and contribute to scientific research.
- **Utilize Social Media:** Leverage social media platforms to raise awareness about the citizen science projects. Share updates, photos, and success stories to inspire community members to get involved.
- **Provide Regular Updates:** Keep the community informed about the progress and findings of the citizen science projects. Regular updates and reports create a sense of ownership and pride in the community's contributions.

Collaboration:

- **Engage Schools and Families:** Collaborate with other schools and involve families in the citizen science projects. Create a network of support that extends beyond the immediate community.
- **Field Trips and Expeditions:** Organize field trips or expeditions to study local natural areas or phenomena. These experiences can foster a deeper connection between the community and the scientific process.
- **Adopt Easy-to-Use Tools:** Choose citizen science projects that utilize user-friendly data collection tools and mobile apps, making it accessible to a broader range of community members.
- **Data Analysis and Interpretation Workshops:** Offer workshops on data analysis and interpretation, enabling community members to understand the significance of their contributions to the scientific research.

Empowerment

- **Create Community Science Hubs:** Establish community science hubs, such as school-based science centres or local libraries, where people can gather to participate in projects and access educational resources.
- **Celebrate Achievements:** Celebrate milestones and achievements of the citizen science projects. Host events to recognize the efforts of community members and showcase the impact of their work.
- **Promote Interdisciplinary Collaboration:** Encourage collaboration between different community groups, such as schools, local organizations, businesses, and government entities. Interdisciplinary efforts can enrich the citizen science experience.

- **Acknowledge and Appreciate Participants:** Show appreciation for the community's involvement by thanking and acknowledging their contributions through certificates, awards, or recognition ceremonies.
- **Sustain Engagement:** Continuously seek ways to sustain community engagement in citizen science beyond individual projects. Foster a culture of ongoing curiosity and scientific exploration.

Good Practices for Building Communities for Climate Change Education

Schools can be a great tool to combat climate change when they establish associations with other, climate change relevant institutions (REF) This section summarizes examples that have been selected as best practices of teacher collaboration with members of the educational community.

Good practice 1: RiuNet

During the academic year 2022-23, three schools analysed the Besòs river (North-East of Spain) using RiuNet, which is an interactive educational tool that guides any citizen in diagnosing the hydrological and ecological state of a river. At the same time, it is a citizen science project as it provides scientific data to the researchers of the Freshwater Ecology, Hydrology and Management Research Group (FEHMlab) of the Department of Evolutionary Biology, Ecology and Environmental Sciences of the University of Barcelona.
Pedagogical guide (in Catalan): https://www.ub.edu/fem/docs/Riunet/RiuNet_manual_CAT.pdf

Good Practice 2: CleanAir@school

Cleanair@School is an initiative that aims to improve students' knowledge about your exposure to a key air pollutant, nitrogen dioxide (NO2). This is done through citizen science campaigns around the schools in different European countries. Boys and girls from participating schools learn about air pollution and its health effects. The project involved 9 schools and more than 300 students from the city of Girona (Spain) in the preparation and selection of measuring points.
More info: https://www.miteco.gob.es/es/ceneam/ea-otras-unidades/cleanairschools-girona.aspx

Good practice 3: Seeds for the climate

During the academic year 2021-22, several schools in the surroundings of Madrid (Spain) participated in Seeds for the climate, which is a participatory action-research project that revolves around the thematic axis of "adaptation to climate change through the conservation of agrobiodiversity and traditional ecological knowledge". In a first phase, the project focused on the field of natural sciences, since the students were inquiring about how climate influences plant phenology. The action was the planting and cultivation of different local varieties, mostly beans, provided by the local association La Troje. In the second phase, the research focused on the field of social sciences, since the students had the objective of analyzing how traditional ecological

knowledge can help us to detect changes in the climate and improve our climatic resilience. To that goal, students designed and prepared interviews with the elderly and people who farm or have farmed in the area. Then, a seed bank was created in each school, as well as an Inter-school Seed Network, and seeds were exchanged among the participating centers. To that goal, schools collaborated with state seed networks such as Esporus (Manresa) the Center for Ethnobotanical Conservation and the agrobiodiversity of the Sierras de Béjar and Francia-Zahoz– (Salamanca).

- More info: https://germinando.es/lanzamos-semillas-por-el-clima/
- Teaching guide (in Spanish): https://germinando.es/wp-content/uploads/2023/01/SEMILLAS-_POR_EL_CLIMA_GUIA_DOCENTE.pdf

Good practice 4: Lets' count the sparrows (Bulgaria)

The Bulgarian Society for the protection of Birds (BSPB) every year organizes a Citizen Science Campaign Lets' count the sparrows. All volunteers across the country can join the annual campaign, counting for 10 minutes the sparrows they see and putting the numbers on one interactive map.

- For more information: the web site for the campaign is on Bulgarian and is available here: https://www.vrabcheta.bg/.

Behind this initiative is the Bulgarian Society for the Protection of Birds (https://bspb.org/en/), which is the first citizens' nature conservation organization in Bulgaria. Founded in 1988, the

BSPB brings together scientists, university professors and bird lovers, united to take real action for bird conservation.

Up to now the Society works with more than 200 volunteers, including teachers, researchers, school students and local communities. It realizes different Citizen Science campaigns, such as: the mid-winter waterfowl count, the common birds monitoring, the white stork count, the Seed of love campaign, the Let's count the sparrows' campaign and other assessment activities that provide data for scientifically based conservation and for policies for the sustainable management of natural resources.

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Chapter 5: Building an E-learning Platform for Teachers

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Abstract: This chapter discusses the potential of e-learning platforms for climate change education, with a focus on Moodle as the chosen technological foundation. It highlights Moodle's responsive design, collaborative features, assessment tools, and certification options as key characteristics for effective teacher training in climate change education. It also explores the incorporation of interactive content, gamification, and inquiry-based learning within the platform. Furthermore, the chapter outlines best practices for creating user-friendly interfaces, ensuring high-quality content, and fostering community interaction while providing recognition through certifications and badges.

Introduction

In recent times, the increasing urgency to confront the challenges of climate change has become more apparent than ever. This underscores the necessity of educating upcoming generations about the complex nature of this global issue. To effectively spread awareness and understanding about climate change, it is of paramount importance to provide educators with the essential skills and knowledge. An e-learning platform stands out as a potential tool to achieve this objective. Darling-Hammond et al. (2017) reviewed 35 rigorous studies showing a positive connection between ongoing teacher professional development and improved teaching practices and student performance. From this analysis, they identified seven key elements for effective professional development: a focus on content, active learning, teacher collaboration, effective practice models, coaching and expert support, opportunities for reflection and feedback, and sustained duration. In addition, in their 2019 study, Powell and Bodur pinpoint the following key design and implementation aspects for effective online teacher professional development: encourage interaction and collaboration to engage all learners within online communities; incorporate authentic tasks and activities that mirror real-world classroom situations, reflecting teacher practice; integrate reflection to help participants relate new information to their specific teaching contexts.

Within the scope of the ClimaTePD Project, the selection of the most appropriate technological foundation for the e-learning platform has led to the identification of Moodle. A systematic review on trends in using Moodle for teaching and learning (Gamage, Ayers, Behrend, 2022) shows that Moodle is mainly used within University STEM disciplines and effectively improves student performance, satisfaction, and engagement. Moodle is increasingly being used as a platform for adaptive and collaborative learning and used to improve online assessments. Athayaa H. et al.(2021) emphasize the importance of a stable, straightforward, and user-friendly system such as Moodle to support both partially and fully online learning. They also recommend enhancing this system with interactive plugins to improve communication. This open-source Learning Management System (LMS) offers a wide array of features that can be leveraged to construct a comprehensive and captivating e-learning platform aimed at training educators in climate change instruction. Moodle's interface is not only easy to use but also highly customizable, ensuring that both technologically adept educators and those less acquainted with online learning can seamlessly navigate the platform. This flexibility is particularly crucial when catering to a diverse group of

teachers who possess varying degrees of technological proficiency. Furthermore, Moodle inherently supports the establishment of a multilingual environment.

Moodle Key Characteristics and Features

Moodle's User-Friendly Interface: Moodle boasts a user-friendly interface that promotes ease of use and navigation. Teachers participating in climate change training can effortlessly access course materials, discussion forums, and assessment tools. This intuitiveness fosters a positive learning experience, ensuring that teachers remain engaged and motivated throughout their training.

Responsive Design: In an era where learners access content across various devices, Moodle's responsive design ensures that the e-learning platform is accessible on desktops, laptops, tablets, and smartphones. This flexibility accommodates educators' preferences for learning on different devices, enhancing the overall learning experience.

Collaborative Features: Collaborative learning is a cornerstone of effective education. Moodle facilitates collaboration through features such as discussion forums, wikis, and group activities. In the context of climate change education, teachers can engage in discussions, share resources, and collaboratively brainstorm teaching strategies, enriching their understanding of the subject matter.

High-Quality Content: Moodle enables instructors to deliver high-quality content, including text, multimedia, and interactive elements. For climate change training, educators can incorporate videos, infographics, and case studies to elucidate complex concepts and enhance engagement.

Assessment and Feedback: Moodle offers a range of assessment tools, including quizzes, assignments, and polls. These features are invaluable for evaluating teachers' comprehension of climate change topics. Additionally, timely and constructive feedback provided through Moodle's interface aids in their continuous improvement.

Certification/Recognition: Moodle allows for the issuance of certificates upon completion of training modules. This feature not only motivates teachers but also provides them with tangible evidence of their expertise in teaching climate change, potentially enhancing their credibility within educational circles.

Engagement Strategies: Moodle supports diverse engagement strategies, including discussion forums, peer assessment, and interactive simulations. These strategies can be effectively utilized to foster engagement in climate change training. For instance, educators can participate in online debates about climate change policies or simulate real-world scenarios to enhance their problem-solving skills.

Moodle Core Activities and Plugins for Effective Training

Moodle Core Activities: Moodle offers a range of core activities that can be tailored to climate change education. For instance, the "Forum" activity can be used for discussing the implications of climate change policies, while the "Quiz" activity can assess teachers' understanding of key concepts. The "Assignment" activity can be leveraged to encourage teachers to research and present innovative teaching methods for climate change topics.

Digital Tools: Moodle's plugin ecosystem offers a plethora of digital tools that can be integrated to enhance climate change training. The "H5P" plugin allows for the creation of interactive content such as quizzes, presentations, and interactive videos, games, and a variety of other interactive elements. Educators can employ this plugin to create engaging and informative climate change lessons that involve active participation.

Gamification: Gamification is now widely recognized as a pivotal feature in modern LMSs. Existing literature reveals that numerous researchers have highlighted the potential of gamification in e-learning as a means to enhance student engagement and motivation, as demonstrated in studies by AL-Smadi (2015) and Poondej and Lerdpornkulrat (2019). Moodle's "Level Up!" plugin enables the incorporation of gamified elements into the training process. For instance, teachers can earn points and badges for completing modules related to different aspects of climate change education.

Things to consider when creating an e-learning platform for teachers.

The course design process involves several key activities, including: identifying learning objectives; developing operational definitions by translating these objectives into session outcomes; creating engaging and challenging activities, including assignments and exams, aligned with the learning objectives; identifying and producing learning resources, such as reading materials and multimedia content; organizing course modules in a coherent and logical manner. (Eom, Ashill, 2018)

Create a User-Friendly Interface

The platform should have an intuitive and user-friendly interface that is easy for teachers to navigate. This includes clear navigation menus, logical organization of content, and an overall design that facilitates a smooth learning experience. Teachers participating in climate change training should effortlessly access course materials, discussion forums, and assessment tools. This intuitiveness fosters a positive learning experience, ensuring that teachers remain engaged and motivated throughout their training.

Creating a user-friendly interface in Moodle involves thoughtful design, organization, and customization of the platform's elements to enhance the user experience. Here are some steps you can take to create a user-friendly interface:

- Choose a User-Friendly Theme: Start by selecting a Moodle theme that is clean, responsive, and user-friendly. Moodle offers several themes that prioritize usability and aesthetics. While functionality is paramount, an aesthetically pleasing design can contribute to a positive overall user experience. Ensure that the theme you choose adapts well to different screen sizes and devices, ensuring a consistent experience whether users are on desktops, tablets, or smartphones.
- Simplify Navigation: Streamline the navigation menu by including only essential links. Use clear and concise labels that users can easily understand. Group related items under logical headings to make navigation intuitive.
- Consistent Design Elements: Maintain consistency in design elements such as buttons, icons, colors, and typography throughout the platform. Consistency helps users develop patterns and expectations for interacting with the interface.

- Prioritize Content: Arrange content in a structured manner. Use headings, subheadings, and appropriate formatting to break up text.
- Clear Call-to-Action (CTA): Use visually prominent buttons for important actions, such as "Login/register", “Go to Learning Unit X" or "Submit Assignment." Ensure that CTAs stand out and are easy to click.
- Reduce Clutter: Avoid overwhelming users with too much information on a single page. Keep layouts clean and minimize unnecessary elements. Focus on presenting the most relevant content.
- Use White Space: Incorporate sufficient white space between elements to provide visual breathing room. White space enhances readability and makes the interface feel less crowded.
- Readable Typography: Choose a legible font and size for text. Make sure text contrasts well with the background. Avoid using too many fonts; stick to a consistent typography scheme.
- Feedback and Validation: Provide immediate feedback when users take actions, such as submitting an essay or completing a quiz. Use validation messages to guide users and let them know their actions were successful.
- Sensible Course Organization: Structure learning units in a logical sequence, using clear section headings and consistent formatting. Provide a syllabus or introductory materials to help users understand the course layout.
- Easy Access to Resources: Organize course resources in a clear and intuitive way. Use labels, icons, and formatting to make it easy for users to identify and access materials.
- Testing and Feedback: Test the interface and the platform's responsiveness on different devices with a group of teachers to gather feedback on its usability. Use their insights to identify areas for improvement and refine the design.
- Regular Updates: Keep the online platform and its themes/plugins up to date to ensure compatibility, security, and access to new features that contribute to a better user experience.

Ensure High-Quality Content

Ensuring high-quality content in a course for teachers regarding climate change requires careful planning, research, and the incorporation of effective teaching strategies. Here are steps you can take to create a high-quality course:

- Define Learning Objectives: Clearly define the learning objectives for your course. What should teachers be able to know and do after completing the course? Objectives help guide content creation and ensure alignment with learning outcomes.
- Thorough Content Research: Conduct thorough research on climate change topics to ensure accuracy and currency of information. Use reputable sources, scientific research, and up-to-date data to inform your content.
- Engaging Multimedia: Incorporate a variety of multimedia elements such as videos, animations, infographics, and interactive simulations to engage teachers and illustrate key concepts effectively.
- Structured Learning Units: Organize your course into structured learning units that focus on specific topics related to climate change. Each learning unit should have a clear introduction, learning objectives, content, activities, and assessments.

- Interactive Activities: Include a mix of interactive activities like discussions, quizzes, case studies, group projects, and reflective exercises to engage teachers and encourage active learning.
- Real-World Examples: Integrate real-world examples and case studies that demonstrate the impact of climate change in different contexts. This makes the content more relatable and relevant.
- Guest Speakers and Experts: If possible, invite guest speakers or experts in climate change to contribute to your (blended) course. Their insights and experiences can provide valuable perspectives.
- Expert Interviews: Record video interviews with experts to provide deeper insights into specific climate change topics. These interviews can be incorporated into your course modules.
- Discussion Forums: Create discussion forums where teachers can share their thoughts, insights, and questions about climate change. Encourage meaningful discussions that promote critical thinking.
- Clear and Concise Language: Use clear and concise language to explain complex concepts. Avoid jargon and explain technical terms for teachers who may not have a strong background in the subject.
- Regular Updates: Keep the content up to date with the latest research, developments, and trends in climate change. Include current events and news related to climate issues.
- Feedback and Assessment: Provide regular opportunities for teachers to assess their understanding through quizzes, assignments, and assessments. Offer constructive feedback to guide their learning.
- Resources and References: Provide a curated list of resources (repository), readings, and references that teachers can explore for further learning. This empowers them to continue their education beyond the course.
- Incorporate IBL and Gamification: Integrate inquiry-based learning (IBL) approaches and gamified elements to make learning interactive and engaging.
- User Testing: Test your course with a small group of teachers to gather feedback on the content, activities, and overall user experience. Use their input to make improvements.

Create Interactive Content

Moodle offers several tools and features that allow you to create interactive content and engage teachers within your courses. Here are some of the key tools you can use to create interactive content in Moodle:

- H5P Integration: Moodle has a built-in integration with H5P, a powerful tool for creating a wide range of interactive content types such as quizzes, interactive videos, interactive presentations, interactive timelines, and more. With the H5P plugin, you can easily add these interactive elements to your course.
- Quiz Activity: Moodle's Quiz activity allows you to create various types of quizzes, including multiple-choice, true/false, short answer, and essay questions. You can also include interactive question types like matching, drag-and-drop, and numerical questions to make the assessment more engaging.
- Assignment Activity: The Assignment activity lets you create tasks where teachers can submit files, documents, or other forms of work. You can provide feedback and grades, encouraging teachers to apply their knowledge and skills.

- Workshop Activity: The Workshop activity supports peer assessment. Teachers can submit their work, review the work of their peers, and provide feedback based on predefined assessment criteria.
- Interactive Lessons: Moodle's Lesson activity allows you to create interactive scenarios where teachers progress through different paths based on their choices and responses. This is ideal for creating branching scenarios or interactive stories.
- Glossary Activity: You can use the Glossary activity to create collaborative glossaries where teachers contribute definitions, explanations, or terms related to the course content. This encourages active participation and collaboration.
- Database Activity (Repository): The Database activity allows teachers to contribute and search for content, such as case studies, examples, or resources. It's a great way to engage teachers in creating a repository of practical knowledge.
- Wiki Activity: The Wiki activity enables collaborative content creation. Teachers can contribute to a shared wiki by adding and editing content, which can be useful for collaborative projects or group research.
- External Tools (LTI Integrations): You can integrate external tools and applications using the Learning Tools Interoperability (LTI) standard. This can include virtual labs, simulations, coding environments, and more, providing hands-on experiences directly within Moodle.
- Virtual Classroom (Web conferencing tools): If you're using virtual classroom tools like BigBlueButton or Zoom, you can integrate these tools into Moodle. This provides a platform for real-time discussions, collaborative activities, and hands-on demonstrations.
- Gamification Plugins: Moodle offers gamification plugins that can encourage hands-on participation. For instance, you can award badges or points to teachers for completing assignments, quizzes, or other activities.
- Embedded Multimedia: Incorporate interactive multimedia content, such as simulations, interactive maps, and virtual tours, directly within your Moodle course pages to enhance hands-on learning experiences.
- Questionnaire activity: The Moodle Questionnaire module allows you to survey Moodle course participants. It allows instructors to create a wide range of questions to get teacher feedback. It supports conditional branching so it can be used to build “wizards” and guide teachers to complete an assignment.

Track Progress and Assess Learning

Moodle offers various tools and features to track progress and assess learning within courses. These tools help both teachers and instructors monitor engagement, performance, and completion of activities. Here are the key tools for tracking progress and assessing learning in Moodle:

- Gradebook: The Gradebook is a comprehensive tool for instructors to manage and track teachers' grades. It provides a central place to input, calculate, and display grades for assignments, quizzes, discussions, and other activities.
- Activity Completion: Moodle allows instructors to enable activity completion tracking. This feature lets teachers and instructors see which activities have been completed and which are pending. It provides a visual indicator of progress.

- Progress Bar: Moodle's Progress Bar block provides teachers with a visual representation of their progress in the course. It shows the percentage of completed activities and encourages teachers to complete the remaining tasks.
- Quiz Statistics: Instructors can access quiz statistics to review teachers' performance on individual quiz questions. This helps identify challenging areas and provides insights into question effectiveness.
- Assignment Submissions: Instructors can access individual assignment submissions, view submitted files, provide feedback, and assign grades. This allows for detailed assessment and tracking of assignment progress.
- Discussion Forums: Moodle's discussion forums track participation and allow teachers to see their own contributions. Instructors can assess the quality of teachers' posts and engagement.
- Self-Assessment Tools: Moodle activities like quizzes can be set up for self-assessment, allowing teachers to review their own understanding before attempting formal assessments.
- Badges and Certificates: Moodle allows instructors to issue badges and certificates upon completing certain activities or achieving specific milestones. These can serve as visual recognition of progress.

Encourage Community Interaction

Creating community interaction in Moodle involves fostering a sense of collaboration, engagement, and communication among teachers within your course. Moodle provides several tools and features to facilitate community interaction. Here's how you can encourage community engagement in Moodle:

- Discussion Forums: Discussion forums are a central tool for community interaction in Moodle. Create different forum topics for teachers to discuss course content, ask questions, share insights, and collaborate on projects. Encourage active participation and facilitate discussions by posing thought-provoking questions.
- Group Activities: Create groups within your course and assign group activities. Group members can collaborate on assignments, discussions, projects, and more. Group activities provide a more intimate space for interaction and collaboration.
- Peer Assessment and Workshop: Use the Workshop activity to facilitate peer assessment. Teachers can review and provide feedback on each other's work, fostering a sense of community-driven evaluation.
- Messaging: Enable the messaging feature to allow teachers to send private messages to each other as well as to their instructor. This can be particularly useful for peer communication, group coordination, and discussing course-related matters.
- Chat: Use the Chat activity to schedule real-time text-based chats. This can facilitate live discussions, Q&A sessions, and synchronous interaction among teachers.
- Web Conferencing: Integrate web conferencing tools like BigBlueButton or Zoom for live video discussions, virtual office hours, and collaborative sessions. These tools allow teachers to interact face-to-face online.
- Social Media Integration: If your Moodle site supports it, integrate social media features to encourage sharing, networking, and community building among teachers.

- Wikis: Encourage teachers to collaborate on a wiki to create and edit content together. This can foster a sense of shared ownership and contribution.
- Blogs: Allow teachers to create individual or group blogs where they can reflect on course content, share insights, and engage with their peers' thoughts.
- Online Workspaces: Use collaborative online tools like Google Workspace (formerly G Suite) or Microsoft 365 and integrate them into your Moodle course. Teachers can work together on documents, presentations, and spreadsheets.
- Discussion Prompts: Pose open-ended discussion prompts that encourage teachers to share personal experiences, insights, and perspectives related to the course content.
- Polls and Surveys: Create polls and surveys to gather teachers' opinions, preferences, and feedback. This engages teachers and gives them a voice in shaping the course experience.
- Facilitate Online Events: Organize virtual events like guest speaker sessions, panel discussions, or webinars. These events provide opportunities for teachers to interact with experts and peers.
- Database Activity: Use the Database activity to create a collaborative resource repository where both instructors and teachers can contribute resources. Teachers can search, filter, comment and download resources from this database.

Offer Certification and Recognition

Moodle offers various tools and features that allow you to offer certifications and recognition to teachers who successfully complete your courses. Providing certificates and badges can motivate teachers and validate their achievements. Here are the key tools you can use to offer certification and recognition in Moodle:

- Badges: Moodle's built-in Badges feature allows you to create custom badges that teachers can earn for completing specific activities, achieving milestones, or demonstrating certain skills. Badges are visual representations of achievement that teachers can display on their profiles.
- Certificates: Moodle's Certificate module enables you to generate printable certificates that teachers receive upon completing a course or meeting specific criteria. You can customize the design, content, and format of the certificates.
- Completion Tracking: Moodle's completion tracking feature allows you to define completion criteria for activities and resources within your course. When teachers meet these criteria, they receive a "completion" status, which can be used as a basis for offering recognition.
- Course Completion: In Moodle, you can set up courses to mark as "complete" when teachers finish all required activities and resources. This can trigger automatic awarding of certificates or badges.
- Gradebook Integration: You can tie certifications and badges to specific grade outcomes. For instance, teachers who achieve a certain grade can automatically receive a badge or certificate.
- Custom Activities: Create custom activities or assessments that teachers must complete to earn recognition. This could include final projects, quizzes, assignments, or presentations.
- Conditional Activities: Set up conditional activities based on teacher performance. Once teachers meet specific criteria (e.g., complete a quiz with a certain score), they can gain access to a certificate or badge.

- External Badge Services: Integrate external badge services like Open Badges or Credly with Moodle to issue digital badges that can be shared across different platforms and online profiles.
- Progress Tracking: Moodle's tracking tools help teachers monitor their own progress and completion status, motivating them to complete activities and earn recognition.

Conclusion

Moodle stands as a powerful tool for creating an e-learning platform to train teachers in teaching climate change. Its user-friendly interface, responsive design, collaborative features, quality content delivery, assessment tools, certification options, engagement strategies, and technical support make it an ideal choice for imparting crucial knowledge in this area. Leveraging Moodle's core activities and plugins further enhances the training experience, allowing for the integration of digital tools, gamification, and IBL techniques tailored to climate change education. By harnessing the capabilities of Moodle, educators can effectively equip themselves with the skills and knowledge required to educate the next generation about the urgent challenge of climate change.

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Chapter 6: Implementing Design Thinking Process for Climate Change Education

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Abstract: Understanding climate change requires a holistic perspective of the environment. Design thinking is an analytic and creative problem-solving process that engages a person in opportunities to make something physical and/or digital that matters. In this chapter, we discuss design thinking and the possible implementation of this process in climate change education.

Introduction

Design thinking is a problem-solving methodology that involves understanding the needs and behaviors of users, identifying opportunities, generating creative solutions, and testing and refining those solutions. It is a human-centered, iterative process that encourages collaboration, experimentation, and empathy. Design thinking is often used in product design, but it can be applied to many different fields, including education. In education, design thinking is a process that encourages teachers and students to think creatively and collaboratively to solve problems.

Design Thinking Process for Education

Design thinking in education is a powerful tool for developing critical thinking, problem-solving, and collaboration skills in students. In innovation-focused sectors, design thinking is commonly used as a method to build innovation ecosystems (Plattner et al., 2014). By using design thinking in the classroom, teachers can engage students in meaningful, real-world problem-solving activities that prepare them for success in their future academic and professional endeavors.

There are several popular design thinking models that can be adapted for use in education. Here are a few examples:

- **Stanford d.school Design Thinking Process:** The Stanford d.school's design thinking process is a well-known and widely-used model for design thinking in education. It consists of five stages: empathize, define, ideate, prototype, and test.
- **Design Thinking 4 Education:** The Design Thinking 4 Education model[5], developed by **Harvard Graduate School of Education**, is a six-step process that includes: framing the challenge, observing users, synthesizing insights, generating ideas, prototyping solutions, and testing with users.

[5] https://tll.gse.harvard.edu/design-thinking

- The **Design Thinking for Educators Toolkit**[6] was developed by IDEO in collaboration with Riverdale Country School and consists of five phases, which are discovery, interpretation, ideation, experimentation, and evolution. IDEO also developed the Co-Designing Schools Toolkit, which supports educators to collaboratively create equitable change in schools through a community-led, equity-centered, and design-driven process.

The Stanford d.school Design Thinking Process

The Stanford Design Thinking Process is a widely-used model that consists of four broad stages: *understand* a need or problem, *explore* a need, opportunity, or solution, *materialize* a found solution (e.g., a product or process), and *refine* the context within which the solution is implemented, tested and optimized (see Figures 1 & 2). The process includes six phases: empathize, define, ideate, prototype, test, and assess. These phases do not have to be passed through one after the other in a linear order but can be arranged and repeated as needed to come to a solution. By applying the design thinking processes to learning situations, students can understand and train to approach identified problems through an analytic yet also creative process and can experience innovation-oriented ways of working. In the following, the six phases of design thinking are described.

Empathy: The first phase involves developing an understanding of the people involved in the problem, including students, teachers, and other stakeholders. This phase requires asking questions, observing, and listening to understand the experiences and perspectives of others. The following questions can be considered during this phase:

- What is the challenge that needs to be solved?
- What problem does it create?
- Who are the end users or who is the problem?

Define: The second phase involves defining the problem or challenge. This requires identifying the root causes of the problem and developing a clear problem statement that can guide the rest of the process. Students define and state the problem that requires solutions to methodize their actions.

Ideate: The third phase involves generating ideas for potential solutions. This phase encourages participants to think creatively and generate a wide range of ideas. Students present their ideas through active dialog and discussion. The following questions can be considered during this phase:

- What is the real problem? What are the possible solutions? Generate at least five possible solutions and discuss them with your friends. Choose the best one among them.

[6] https://page.ideo.com/design-thinking-edu-toolkit

- What are the design constraints?
- How can we make this easier/functional/aesthetic/economical/simple/environmentally friendly?

Prototype: The fourth phase involves creating prototypes of potential solutions. This phase allows participants to test and refine their ideas. Students suggests solutions. This is an iterative process that may need to be repeated.

Test: This stage involves testing the prototypes to determine their effectiveness. The following questions can be considered during this phase:

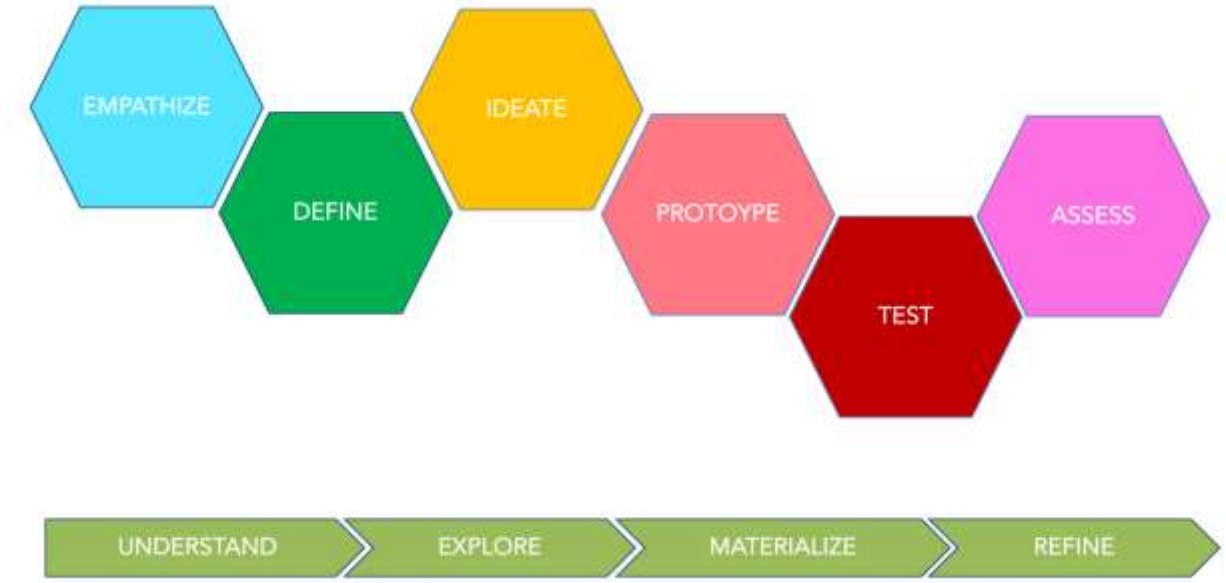
- Test the prototype and gather information. How will you record the data and analyse your results? Evaluate results, improve the design, retest and re-evaluate to make your design even better.
- What worked well?
- What did not work well? What are the main issues with the product? How can you address these and make something that works better?
- What did you discover interesting or different about the product during the testing phase?

Assess: This phase requires gathering feedback from stakeholders and making modifications to the solutions as needed. This phase focuses on giving and receiving feedback, integrating the feedback into the solution/design, refining it, and considering how to add value to it. The following questions can be considered during this phase:

- What problem did your design solve?
- What need did your design fulfill?
- How would you trade off less important features for those that are more important, or balance social, political, cultural, and ecological considerations?
- How does this work and why is it better than existing solutions?
- What are the advantages and disadvantages of your design?

Figure 6.1

A modified version of the Stanford d.school's design thinking process diagram (dschool.stanford.edu)



Using Design Thinking Approach to Teach Climate Change

By using design thinking to teach climate change, you can help your students develop a deep understanding of the problem, as well as critical thinking and problem-solving skills. Additionally, by encouraging students to think about potential solutions and testing them out, you can inspire them to become active agents of change who are empowered to make a difference in addressing the issue of climate change. Throughout this process, students should also be encouraged to reflect on their experiences and learning. For example, they could reflect on how their understanding of climate change and its impact on different stakeholders has changed throughout the design thinking process.

Here's an example of how a design thinking approach could be applied to teaching climate change:

1. **Empathize:** Start by encouraging students to empathize with stakeholders who are affected by climate change. This could include people in communities affected by wildfires, droughts, or rising sea levels such as farmers or coastal communities. Students could conduct interviews or research to better understand the experiences and perspectives of these stakeholders. Students can also consider how climate change affects the natural world, such as the impact on endangered species or ecosystems.
2. **Define:** Next, based on the insights gained during the empathize stage, students could define the problem or challenge they want to address related to climate change. This could be a specific issue, such as the impact of rising sea levels on coastal communities, or a broader issue, such as the lack of public awareness of climate change.

3. **Ideate**: In this stage, students should generate a wide range of potential solutions to the problem identified in the define stage. This could involve brainstorming sessions for a wide range of solutions, such as reducing carbon emissions, using renewable energy sources, or promoting sustainable lifestyles. Encourage, sketching, or other ideation techniques.
4. **Prototype**: Students should select one or more potential solutions and turn them into prototypes that can be tested and refined. This could be anything from designing a community engagement project to conducting experiments, creating simulations or engaging in role-playing activities to simulate the implementation of their solutions.
5. **Test**: Finally, students should test their prototypes with real users, such as other students, teachers, or community members. This could involve conducting focus groups, surveys, or other evaluation methods to gather feedback on their solutions and use this feedback to iterate and improve their prototypes.

What students' attitudes and design thinking is focused on?

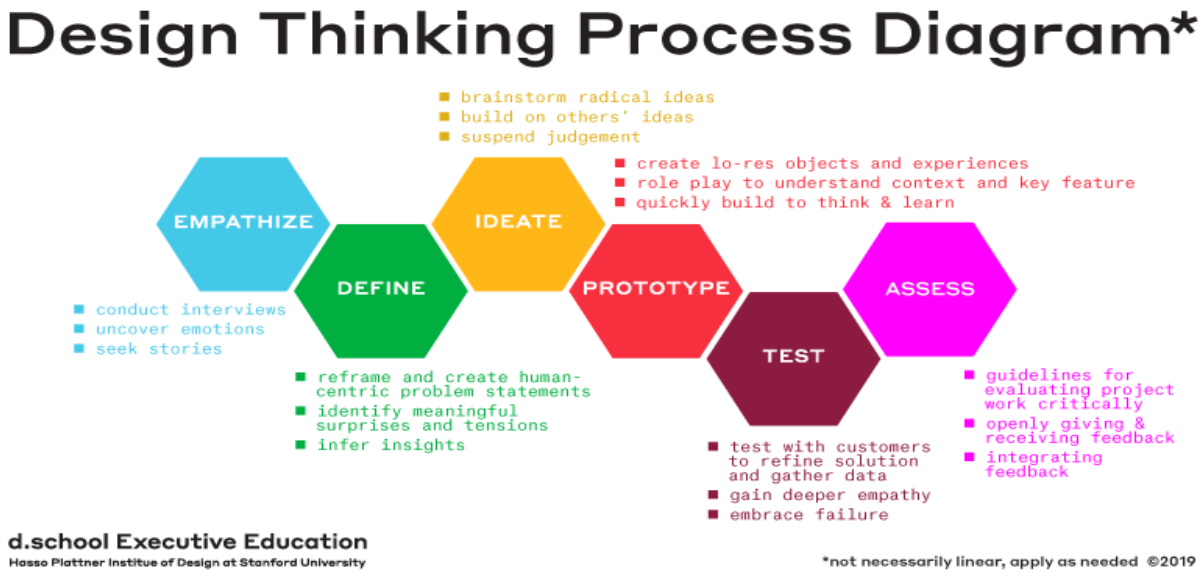
Design thinking fosters several attitudes in students, which can help them become better problem-solvers, collaborators, and innovators. Here are some of the attitudes that design thinking can foster in students:

- **Empathy:** Design thinking encourages students to understand the needs and perspectives of others. Students who embrace design thinking tend to be more empathetic towards others and may be more likely to take others' needs and opinions into account when problem-solving.
- **Curiosity:** Design thinking encourages students to be curious and ask questions, even if they don't know the answers. This attitude helps students to be open-minded and willing to explore new ideas and solutions.
- **Creativity:** Design thinking encourages students to be creative and come up with new and innovative solutions to problems. This attitude helps students to be more imaginative and inventive in their thinking.
- **Collaboration:** Design thinking encourages students to work collaboratively with others to solve problems. This attitude helps students to be more effective communicators and team players.
- **Persistence:** Design thinking often involves prototyping and testing ideas, which can lead to failures and setbacks. Students who embrace design thinking tend to be persistent and resilient, willing to learn from failures and keep working towards a solution.
- **Flexibility:** Design thinking involves iteration and adapting to new information. Students who value design thinking tend to be flexible and open-minded, willing to adapt and pivot their solutions based on new information.
- **Open-mindedness:** Design thinking requires students to be open to new ideas and perspectives, and to be willing to challenge their own assumptions.

- **Iteration:** Design thinking involves a process of iteration, where students test and refine their ideas through prototyping and feedback.
- **Nonjudgmental:** Students should refrain from making assumptions or judgments about people, ideas, idea creators, or situations.
- **Ambiguity:** Students need to be comfortable with ambiguity and uncertainty, and be willing to explore different possibilities and perspectives.

Figure 6.2

The Stanford d.school's design thinking process diagram (dschool.stanford.edu)



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Chapter 7: Global Climate Change Disaster Literacy

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Abstract: Understanding the impacts of global climate change, the threats it will pose in the short and long term, and making and implementing the right decisions to solve the problem are of utmost importance for sustainable life on earth. The most important way to achieve this is to ensure literacy for all stakeholders in the relevant field. First, this section discusses the reasons for preferring the concept of global climate change disaster literacy over global climate change literacy. Then, a model for global climate change disaster literacy is proposed. This model's main dimensions, categories, and subcategories are briefly introduced. At the end of the chapter, an opinion on who should have the necessary competencies in global climate change disaster literacy was shared.

Introduction

Literacy is defined by The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2023) as the "ability to identify, understand, interpret, create, communicate, compute and use printed, and written materials associated with varying contexts. Literacy is a continuum of learning and proficiency in reading, writing, and using numbers throughout life. It is part of a larger set of skills, including digital skills, media literacy, education for sustainable development and global citizenship, and job-specific skills." Literacy, indispensable for education and personal development, is a fundamental characteristic that enables individuals to perceive the world and communicate effectively in modern societies.

When we think of the Earth we live on as a total habitat, the biosphere, we must accept the system as a living organism that functions flawlessly in all its elements, with its matter and energy cycle, food chain, and food webs. However, this system, which has been functioning in an extraordinary way since its creation, is dying due to the selfish and destructive effects of human beings, and its reaction is manifested in the form of temperature increase, extreme weather events, melting of glaciers, decrease in water and food resources, and deterioration in ecosystems. The name of this change, reaction, and/or disaster is global climate change.

Global Climate Change or Global Climate Change Disaster Literacy

Global climate change is the long-term and systematic change in the Earth's climate system. However, due to the fact that the harmful and destructive effects of these long-term changes are felt by everyone to a greater or lesser extent and the ecological, social, and economic impacts of these changes, global climate change has entered everyone's agenda as a key concept/topic. The concept of global climate change (or climate change) literacy essentially refers to lifelong learners acquiring basic knowledge about global climate change, developing skills such as research-inquiry, critical thinking, problem-solving, and decision-making, examining the long-term consequences of climate change, and demonstrating curious, responsible and solution-oriented behaviors on these issues. Global climate change literacy also encompasses the knowledge, skills,

attitudes, values, and understandings individuals and societies need for a sustainable life. This statement should be binding not only on individuals but also on society and institutions.

Although there are different definitions or explanations of climate change in the literature that are thought to serve the same purpose (climate change literacy, climate literacy, global climate change literacy, etc.), should the concept of global climate change disaster literacy or global climate disaster literacy be the key concept that should be used first, considering its destructive and widespread effects? From John P. Holdren's (2007) point of view, former senior science and technology advisor of Barack Obama, the term "global warming" is a misnomer. "It implies something gradual, uniform, and benign. What we're experiencing is none of these." He uses "global climate disruption" instead. The term "global" is important to emphasize that this issue concerns everyone, every country. However, the concept of change can have a wide range of different meanings. Although it is used differently in different contexts, fundamentally, "change" can mean changing or transforming a situation or condition over time. It gives positive messages even just because of the scope of its meaning. From this point of view, does global climate change create the perception of an issue that has had the most significant impact on humanity from the moment it emerged on earth until today, that is almost irreversible, that has devastating environmental consequences, and that can create a giant ball of problems in social and economic dimensions? In other words, extreme weather events such as temperature increases, hurricanes, floods, droughts, increase in forest fires, decrease in biodiversity and natural resources due to damage to ecosystems, the disappearance of endemic species, migrations, social conflicts, and wars that may occur as a result of disasters in habitats; physical health problems due to heat waves, increase in infectious diseases and nutritional problems; mass human deaths due to food shortages, especially in underdeveloped countries; increased trauma and psychological issues due to frequent disasters and losses; economic damage to infrastructure and building integrity. Does the concept itself carry the unbearable weight of all these negative effects?

In addition to all these negative impacts, there are potential positive impacts of global climate change: Climate change may lead to mild weather conditions or longer growing seasons in some regions. This could positively affect the cultivation of crops and increase productivity. Transportation may become more manageable in the Arctic and northern areas covered by snow and glaciers, and new settlements may emerge. It may lead to faster development of green technologies to reduce carbon emissions, more investment in renewable energy sources, and increased job opportunities. Climate change in some regions may lead to new habitats and the settlement of new species. Rising temperatures may also trigger the decline or disappearance of some disease vectors. Cold-related deaths may decrease, especially in winter. It should be noted that most of the positive aspects are specific to certain regions and reflect exceptional circumstances.

While some scientists and economists maintain their views on the positive impacts of global climate change, a large majority today would argue that the potential benefits are easily negligible compared to the negative impacts outlined earlier. As stated in the US Climate Literacy, The

Essential Principles of Climate Sciences (USRCRP, 2009), *If warming exceeds 2 to 3°C (3.6 to 5.4°F) over the next century, the consequences of the negative impacts are likely to be much greater than the consequences of the positive impacts.*

Dimensions of Global Climate Change Disaster Literacy (GCC Disaster Literacy)

Because of the previously emphasized reasons, the impact that the concept may create in minds at first glance, and its potential to develop adequate perceptions of global climate change, the idea of GCC Catastrophe Literacy was adopted in this study. We can classify GCC Disaster Literacy into four primary dimensions: knowledge, skills, affect, and behavior (Table 1). Different literacies have used these main dimensions, especially environmental literacy (Hsu, 1997; Erdoğan, Marcinkowski & Ok, 2009). Considering the four main dimensions, the categories in each main dimension, and the related subcategories, it can be predicted that GCC Disaster Literacy is a multi-layered subject that spans a wide range. The knowledge dimension covers basic knowledge of climate, climate policies, sustainable development principles, and multidisciplinary/interdisciplinary approaches. Skills cover the abilities required to accomplish a job or task, ranging from cognitive and communication skills. Creative thinking, critical thinking, innovative thinking, entrepreneurship, collaboration, and digital skills are crucial for developing, applying, and adapting GCC Disaster Literacy in different fields. The affective dimension includes attitudes, values, and understandings of GCC Disaster Literacy. It consists of the internal factors behind emotional responses. Of course, behaviors are where all these knowledge, skills, and affective dispositions turn into action. Responsible and aware individuals, societies, institutions, and all relevant parties who adopt sustainable behaviors in the context of GCC Disaster Literacy are needed today more than ever.

The following points should be noted regarding this approach to GCC Disaster Literacy: The categories and subcategories given in Table 1 for the four primary dimensions can be added (or substituted or subtracted) in line with suggestions from different individuals, organizations, and professional groups. This way, modifiability, and adaptation can enable the model to define and process the components more effectively. In addition, considering that GCC Disaster Literacy should be regarded as for everyone, categories, and subcategories for all age and occupational groups from kindergarten to the end of university can be addressed regarding individuals' mental development levels, socio-cultural factors, individual differences, etc. By determining a basic level of competence for the knowledge, skills, attitudes, and behaviors that need to be addressed in any category and sub-dimension, this can be expanded and enriched for different age and occupational groups. In addition, the detailed preparation of specification tables for each dimension, category, and subcategory can serve to evaluate the adequacy of a course, program, or activity in terms of GCC disaster literacy.

Table 7.1

Dimensions, components, and subcomponents of GCC Disaster Literacy

Dimensions	Components	Subcomponents
KNOWLEDGE	Knowledge of Climate	Key Concepts (*weather, climate, climate change, climate system, global warming, feedback, Carbon cycle, Carbon footprint, etc*.) Key Principles of Climate Science (*as explained in USGCRP, 2009*) Climate types and regions Factors affecting climate Global-local ecosystems/climate relationship
	Knowledge of Climate Policies	Climate policies of his/her own country Climate policies of different countries International agreements Social and political barriers
	Knowledge of Sustainable Development Principles	Environmental sustainability Social justice Economic development Resource efficiency Cultural diversity Renewable energy Diversity and inclusion Education and awareness Global cooperation
	Multidisciplinary-Interdisciplinary Approach of GCC Disaster Literacy	Knowledge of other literacies (*Science and technology literacy, environmental literacy, digital literacy, health literacy, media literacy, e-literacy vb*.) GCC Disaster literacy in the context of Science-Technology-Society-Environment-Individual (STSEI) Interaction STEM, STEAM
SKILLS	Cognitive Skills	Basic-integrated science process skills *(observing, inferring, measuring, communicating, classifying, predicting - controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, formulating models)*
	Psychomotor-Technical Skills	Practical experience Digital skills *(ability to use digital devices, communication applicants, and networks, and manage information)* Design skills related to green technologies
	Creative-Innovative-Entrepreneurial Skills	Ideation, innovation, problem-solving, adaptability, imagination, etc. skills in the context of GCC Disaster
	Critical Thinking Skills	Analytical thinking skills, inquiry-based learning skills
	Cooperative/Collaborative Skills	Working together in a group, each contributing their strengths and efforts towards a shared target/Deeper level of shared ownership and joint decision-making.
	Communication Skills	Skills of verbal and nonverbal communication Interpersonal-public persuasion skills
AFFECT		Moral/ethical values Appreciation and sensitivity for the natural world

	Affective Situation and Tendencies, Sustainability Value	An effort to understand and appreciate different belief and value systems. Willingness to learn and understand. Conscious and responsible decision Solution-focused approach Empathy Willingness to cooperate/organizational participation. Self-control Curiosity
BEHAVIOUR	Conscious/responsible Behaviour Centred on GCC Disaster	Personal and social participation Political participation Taking an active role in actions *(Leadership)* Educational practice behaviors that will raise awareness. Demonstrating a sustainable lifestyle *(sustainable producer/consumer behaviors, sustainable transportation preference, savings, waste reduction, and recycling practices etc.)*

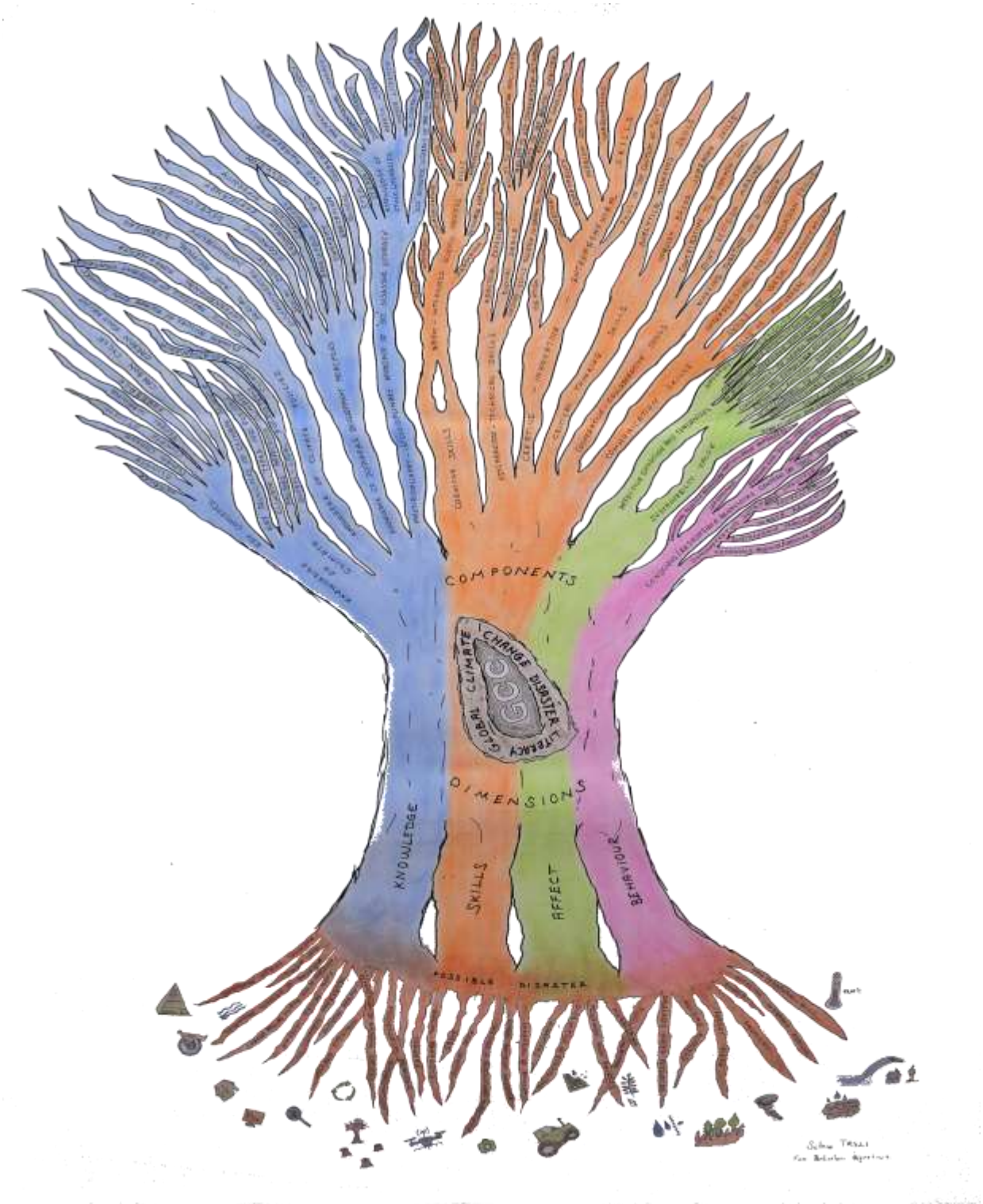
In addition to the categorization given in Table 1, A mind map Figure 1 drawn by a science teacher (her name is Selma Taşlı) shows the components of GCC Disaster Literacy and the catastrophic effects of climate change from her point of view.

For which groups is it a priority to raise awareness on GCC Disaster Literacy?

Global Climate Change Disaster Literacy is vital for everyone. But who should have this competence in the first place?" We should probably list politicians (decision-makers in the governance of the country), teachers, journalists, religious leaders, and parents in the first place. Considering their potential for decision-making, raising future generations, and creating public awareness, efforts to ensure the competencies of these groups on GCC Disaster Literacy can ensure that possible disasters are experienced at the lowest level and low-carbon life in the future.
Especially when we consider teaching as a career profession, how can we make the teachers and pre-service teachers who are already in service individuals sensitive to environmental problems, solution-oriented, and sustainable thinkers regarding Global Climate Change Disaster Literacy? How do we integrate the dimensions of GCC Disaster Literacy into the knowledge, skills, attitudes, values, and behaviors (all of which we define as teacher competencies) that teachers are considered to have for their profession? How will we see teachers of all subjects as part of and stakeholders in this process? Should we start this process, especially in branches such as Science, Social Studies, and Geography? In other words, should we make the above-mentioned ranking of priority groups also among teachers' own branches? How should we accelerate web-based studies on this subject and develop teachers' skills, such as e-literacy and digital literacy, in parallel? Which priorities should we put on the table in socio-culturally and economically disadvantaged regions and countries? Considering that the climate change disaster is a global problem and we are all "citizens of the world," should we set common standards for teacher competencies in the global climate change disaster? Can we see global climate change disaster literacy as a chance for teachers of different colors, thoughts, and beliefs to form a worldwide network so that problems can be discussed and solutions can be presented?

Figure 7.1

A mind map Dimensions, components, and subcomponents of GCC Disaster Literacy



As in this project, many academic studies and every effort in formal and informal learning environments contribute to the correct understanding and rapid response to the global climate change catastrophe.

Since the topic is related to teachers, I would like to give an example of how quickly and negatively global climate change impacts our lives, given the time and potential for impact. 33 years ago, in an academic study, I conducted with 200 prospective primary school teachers (Bahar, 2000), one of the questions was: What do you think are the most important environmental problems facing humanity today? Thirty topics were listed from their response. The topics with the highest frequency were air pollution, nuclear pollution, garbage, deforestation, marine pollution, factory waste, and unplanned urbanization. At the bottom of the list were desertification, loss of agricultural land, energy problems, and unconscious experiments on humans and animals. Changes in climate were mentioned by only 15 students (8%). In other words, it was only in the middle of the list. Thirty years ago, with some exceptions, this finding probably might have been acceptable to a significant proportion of teachers in many countries. However, if we were to ask the same question again to prospective teachers today, we will see the changes in their responses that is, the global climate change, energy problems, and reduction in agricultural areas are at the top of their response list.

In conclusion, learning and teaching global climate change disaster literacy correctly with all its components is vital for everyone who breathes the air, drinks the water, and sets foot on these lands on the only known planet where life exists, namely our Earth. In this learning-teaching process, we can organize it in such a way that it can be a part of an interrelated network with an approach that can be related to key concepts in both science and technology and other disciplines under any umbrella concept (for example, science and technology literacy), we can design the teaching in this way, and we can do the activities accordingly. However, as an alternative to this, we should also consider the possibility that a multidisciplinary/interdisciplinary approach that puts global climate change disaster literacy at the center of the cognitive structure can effectively ensure the acquisition of competencies in the knowledge, attitude, value, and behavior dimensions that global climate change disaster literacy aims to acquire.

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Chapter 8: Climate Activism in the Context of Climate Change and Its Reflections on Education

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Abstract: Climate change has become a serious source of concern and anxiety worldwide, affecting the social structure from environment to economy, agriculture to education. Climate activism, which is carried out to raise public awareness and attract the attention of policymakers in the fight against climate change, includes various actions and campaigns. This section discusses the historical formation of climate activism and its dimensions reflected in education.

Introduction

Climate activism, which is consconsidered a critical strategy used in education systems to raise awareness of young people about climate change, has become a trend zed under the guidance of states. Millions of young people mobilized for a sustainable future by turning climate action into a global movement in 2019 (Neas, 2023; Nissen et al., 2021; Rousell & Cutter-Mackenzie-Knowles, 2019). As climate change pushes ecosystems, economies, and the social fabric of societies worldwide toward chaos, researchers have long echoed calls for rapid societal transformations toward sustainability.

The report published by the Intergovernmental Panel on Climate Change (IPCC) in 2022 emphasized the importance of civil society actions to make the planet more livable in the future. It was also stated that there should be a call for rapid and decisive climate action (IPCC, 2022). Youth climate mobilization, which tends to react quickly, forms the basis of social movement activism (Holmberg & Aida, 2020). It has been emphasized that the only process that massively mobilizes governments is the intense pressure of social movements at the center of climate action (IPCC, 2022).

Cognitive, Affective, and Psychomotor Effects of Climate Activism

As a different dimension of climate change awareness, the impact of the climate crisis on the mental and spiritual health of human beings is gaining importance day by day (Martin et al., 2020; Sanson et al., 2019). In a study conducted by Wright and Hogan (2012) with more than 500 young people from 52 countries, more than 70% of young people (aged 15-25) stated that they felt negative emotions and hopelessness about climate change. Baker, Clayton, & Bragg (2020) stated that activist action processes on climate change are essential for young people and that taking action will buffer negative psychological consequences.

Climate change, in many countries around the world, regional or local, extremes in weather events, and negative processes on natural resources have caused many negative emotional states such as intense anxiety, fear, worry, anxiety and hopelessness in young people of countries with low socio-economic status (MacKay et al., 2020). In their study, Gold & Leckey (2020) stated that climate change education, which includes action processes, can motivate correct action behaviors in young people and that acting as a community reduces negative behaviors that prevent the planet's sustainability.

It is considered necessary for young people to participate in action processes to develop leadership skills such as organizing, public speaking, negotiation, and participation in meetings (Erbstein, 2013). There is a consensus that the climate action movement has created a new way of thinking about power and self-expression among young people.

In general, environmental activism can shape young people as civic actors in society and provide them with the opportunity to learn more about their identity, help them understand their role in society, develop positive self-identity, recognize their talents, and develop a sense of making a difference (Andersen, & Dahl, 2019).

MacKay, Parlee, and Karsgaard (2020) interviewed youth activists from the Canadian North who attended the United Nations Conference of the Parties (COP24) and found that youth engagement reduces concerns about climate change. Intergroup learning opportunities, community support, and newly developed leadership skills are seen as benefits of youth activism, according to data from youth who attended the COP24 meeting in Katowice, Poland. Collaborations between Canadian indigenous youth and youth from different cultures have shown that they can provide opportunities within different groups they cannot reach in their communities. In addition, the improvement in the ability of young people to search for resources and opportunities in search of solutions to problems was found to be noteworthy. Youth action processes are noteworthy as environments where social skills development and self-esteem development are supported, and global teaching and learning opportunities can occur.

Climate Activism and its History

Activism is essential to environmental citizenship, even though it is associated with violent demonstrations and actions where protesters and police clash through the context created through the media (Reis, 2020). In addition, some researchers describe activist movements as collective, democratic, and research-based (Kowasch et al., 2021) and those who characterize ideological divisions between different perspectives and radical demands.

The School Strikes 4 Climate (SS4C) movement, which represents the powerful voice of children and young people (Thomas et al., 2019), has its origins in the Swedish student Greta Thunberg,

who inspired a global movement (Aranoff, 2019). Climate activism represents a historical transformation with a peaceful action that mobilized a generation.

While research has been into the origins and trajectories of social action movements (Giugni, 1998; Amenta et al., 2010), developing an understanding of how, when, and to what extent these actions matter has recently become more critical. In a sense, climate action is now, in Guigni's (1998) words, "worth the effort?"

In studies investigating the problems of sustainability of climate actions, it is stated that there are problems such as firstly the time factor (Bosi & Uba, 2009), secondly, the inconsistency in the outcome of the action (Amenta et al, 2010; Nissen et al., 2000) and finally the inability to determine whether the outcome of the action is due to the movement or other external factors. Bosi, Giugni, and Uba (2016) found that for individuals who participate in social activist actions, this process has strong and lasting effects on their political and personal lives in the long term. Activists tend to continue their socio-political participation throughout their lives, indicating that their social lives, including their family life, circle of friends, and work-career environment, are also affected by activist processes (Vestergen et al., 2017). Environmental activism has a long history in many different areas, ranging from pro-environmental behaviors, environmentally conscious consumerism, social media activism, protest participation, and political participation (O'Connor, 2015; O'Brien et al. 2021; Rootes, 1999).

Recent School Strike for Climate actions around the world (The SchoolStrike4Climate) have highlighted the willingness of young people to act for environmental and broader climate justice issues (Hilder & Collin, 2022). In Australia, for example, around 500,000 people, mostly students, participated in both physical rallies and online actions (Hilder & Collin, 2022), and the rapid and massive actions of school students were reportedly followed with interest by many circles, including politicians (Collin & Matthews, 2021).

Climate Activism in Turkey

Environmental activism, which started in the second half of the twentieth century, has recently been resonating with a broader base as the effects of climate change/crisis have become more pronounced. In 2018, Greta Thunberg, who made a name for herself with the actions she started to carry out in 2018, attracted attention around the world with her wide media coverage and brought a new perspective to climate activism, making climate activism a new agenda in world politics (Yıldırım, 2020).

Climate activism is also evaluated in different contexts in Turkey. However, culturally, activists are not viewed positively across the country. The fact that children and young people are more courageous on this issue is often criticized by adults. Criticism is often based on the roles assigned

to this group by society. Children and young people should go to school, fulfill their responsibilities, and not get involved in matters concerning adults. When these are the expectations, this is where the criticism comes from. *"See, they have confused the minds of young children too? Children are going on strike instead of going to school. They always learn from abroad..."* (Unal, 2019 Page). These criticisms can perhaps be seen as adults' -secret criticism of themselves. Because the climate issue, just like other issues, directly concerns the future of young people.

History of Climate Action in Turkey and Recent Climate Actions

Although climate movement, climate action, and climate activism are considered different titles, they refer to the attitudes and behaviors of societies and the individuals who constitute them in the face of a problem situation. The primary purpose here is that it is a social movement demanding that the necessary measures be taken to minimize the main effects of the climate crisis and that the necessary policies be established to adapt to the new process. It is possible to consider the climate movement from its inception to the present day in four main periods: The emergence period between 1980 and 2000, the formation period between 2000 and 2009, the reshaping period between 2009 and 2017, and the new wave period that started in 2018 and continues today (Kesgin, 2022).

Looking at what has been done in line with the climate movement in Turkey, it seems possible to say that some activities have been carried out in every period. Some examples from the first three periods in the context of the climate movement in Turkey are presented chronologically in Table 1. When Table 1 is analyzed, it can be said that the climate movement in Turkey has created a broader base for itself in the last two decades. Examples from the post-2018 period are discussed in more detail below, as the activities of young activists in this period show a similar development process to countries that take this situation more seriously.

Table 8.1
A Chronological Overview of Some Events in the Process of Climate Action in Turkey (Baykan, 2013)

History	Realized Event
1985	Translation of John Gribbin's book "Climate and Mankind" into Turkish by the Turkish Environment Foundation under the title "Climate and Human."
1995	Open Radio has been drawing attention to climate change since its founding.
2005	Climate activist Jonathan Neale's lectures on global climate change in Istanbul and Izmir on "Stop Global Warming, Make Poverty History
December 2005	Organizing Turkey's first climate change rallies in Istanbul, Ankara and Izmir
February 16, 2006	Launch of the Turkish Greens' climate change campaign (Stop Climate Change, Sustain Life) in coordination with the European Greens' campaign
October 7-8, 2006	The first Climate Change Activist School organized by the Greens of Turkey

November 2006	Organizing a simultaneous rally with 47 countries in Kadıköy, Istanbul, with the call of the Global Action Group, demanding "Stop Global Warming"
February 13, 2007	Greens Announce Climate Change Emergency Action Plan
2007	Publication of "Global Warming and Climate Crisis" by Ömer Madra and Ümit Şahin
2008	Establishment of the Climate Platform, Regional Environmental Center Turkey Office (REC Turkey), and Turkish Industry and Business Association (TÜSİAD) Climate Platform
December 2008	TEMA Foundation is the first NGO from Turkey to have Observer NGO status under the United Nations Framework Convention on Climate Change (UNFCCC)
2009	Marmara University International Relations Research and Application Center (MURCIR) is the first and only university/research institution accredited to the United Nations Framework Convention on Climate Change (UNFCCC) from Turkey
February 2009	Turkey became a side of the Kyoto Protocol.
May 5, 2010	Organizing the First Workshop on Turkey's "National Climate Change Adaptation Strategy" in Ankara, at the then Ministry of Environment and Forestry
December 4, 2010	Organizing a forum on climate change in Izmir by Global Action Group activists
December 8, 2010	Demonstrations organized by Greenpeace Akdeniz and Global Action Group in Istanbul Taksim Square and Izmir Konak Square, calling on Turkey to take the necessary steps in the ongoing climate negotiations in Cancun, Mexico
October 2012	Establishment of the "Climate Network" by Buğday Ecological Life Support Association, Doğa Association, Nature Conservation Center, Eurosolar Turkey, Greenpeace Mediterranean, Kadıköyü Association of Friends of Science, Culture and Art (KADOS), Turkish Foundation for Combating Erosion, Reforestation and Protection of Natural Habitats (TEMA Foundation), WWF-Turkey (World Wildlife Fund), and 350 Ankara to express their common concerns about climate change and to propose solutions together.

Civil society organizations are also stakeholders in climate action in the local context. As an example, from the Turkish context, civil society organizations operating on climate change made a joint statement before the climate summit (COP27) held in Egypt in November 2022. It was announced that for Turkey to reach the net zero target for 2053, at least 35% absolute emission reduction target is required in 2030 compared to 2020 (İklimhaber, 2022a).

Some of the recent climate actions in Turkey are briefly described below.

"Hundreds of thousands of climate activists return to the streets: Turkey and the world's 8th global climate strike" (Üren, 2021)

The protests, which took place in Turkey on September 24, 2021, along with many other parts of the world, were to show that the effects of climate change have not diminished even during the COVID-19 pandemic. Hundreds of thousands of activists worldwide participated in the action called by Greta Thunberg and environmental organizations. During the protests, where the slogan "Change the system, not the climate" came to the forefront, young activists in nine provinces in

Turkey (Adıyaman, Ankara, Bursa, Çanakkale, Muğla, Gaziantep, İzmir, Kahramanmaraş and İstanbul) expressed their demands at many different points in the squares (Üren, 2021).

"Young climate activists on the streets for a livable Turkey" (İklimhaber, 2022b)

Young climate activists worldwide who say "People, not profit" demanded a fairer future at the September 23rd Global Climate Strike. Young activists addressed political decision-makers for Turkey: "For a carbon neutral future, Turkey should aim for at least 35% absolute emission reduction by 2030." A young climate activist also said: "Turkey should set a strong and realistic intermediate target on the road to carbon neutrality in 2053 and go to the 27th climate summit in Egypt in November with a 35% emission reduction target by 2030, as stated by experts in the campaign launched on change.org and supported by us." (İklimhaber, 2022).

"Hundreds of activists addressed political parties at climate action: Climate is no joke" (Pamuk, 2023)

Hundreds of young activists from four different cities in Turkey (Antalya, Denizli, Edirne, and Istanbul) came together on April 1, 2023, to voice their demands from politicians ahead of the upcoming election period. *"Young people have precise demands from all candidates and political parties: They should include actions to combat earthquakes, climate disasters, and the climate crisis among their election promises."* The statements of some of the activists can be listed as follows:

> Young climate activist 1: *"I can say that I became an environmental activist through my work. Seeing so much reality and coming face to face with the fact that the world is inadequate in big systems, production, and consumption has pushed me to be more conscious and strive for the world."*
>
> Young climate activist 2: *"When this stability is disturbed, people's worries about the future increase. Will we run out of water in the future? Will we go hungry? Will food inflation increase?"*
>
> Young climate activist 3: *"As young climate activists, as local NGOs and youth organizations in Turkey, we want to contribute to the 2030 targets and Turkey's climate struggle. In this process, we are here to make the voice of young people heard all over Turkey and the world."* (Pamuk, 2023).

Although the wording and examples vary in the calls of these young activists, the common point is the emphasis on the climate crisis. The effects of the climate crisis have recently been felt concretely in extreme weather events and the course of temperatures outside seasonal norms. From this point of view, demands for more concrete measures to be taken should be considered quite

normal. Especially the concerns of young people on this issue have started to turn into future anxiety. In their words, condemning young people to such a future is "not fair."

In 2023, events such as extreme precipitation in Turkey, floods, and landslides due to this precipitation, extreme temperatures, forest fires due to extreme heat, etc., reveal the current state of the climate crisis. Climate change is an issue that needs to be addressed holistically from local to global, and solutions need to be developed with an interdisciplinary perspective and with the participation of all stakeholders, especially young people. The concept of literacy, which has become increasingly important in education today, aims to teach individuals to use the competencies of the relevant field in solving the problem. In this context, a fundamental skill to be expected from the literate new generation may be to apply what they think, that is, to act.

Some Examples of What has been done in the Local Context of Climate Change in Turkey

As in the rest of the world, climate change is an issue addressed in different contexts in Turkey. The government has taken concrete steps to solve the problems arising from climate change, and the **Ministry of Environment and Urbanization** was renamed as the **Ministry of Environment**, **Urbanization, and Climate Change** by the Presidential Decree published in the Official Gazette dated October 29, 2021, and numbered 31643. The same decree also established the Presidency of Climate Change (Ministry of Environment, Urbanization and Climate Change, 2023). Of course, although the name change alone does not directly contribute to the solution to this problem, it can be seen as necessary in drawing attention to the climate crisis and showing that steps are being taken in this regard.

The Ministry of Environment, Urbanization, and Climate Change (MoEU) has prepared action plans and strategy documents in its work on climate change. "Turkey's Climate Change Adaptation Strategy and Action Plan" (CSB, 2012a) primarily addresses how temperature increases due to climate change will affect Turkey. The main issues addressed are natural resources, human health, agricultural production, and natural disaster risks. Some of the prioritized targets identified in this context are shown in Table 2.

Table 8.2

"Turkey's Climate Change Adaptation Strategy and Action Plan" (CSB, 2012a) Sample Targets

Alan	Priority Target/Target
Water Resources Management	**P 3.** Developing and Disseminating R&D and Scientific Studies to Ensure Adaptation to the Impacts of Climate Change on Water Resources Management
	T 3.2. Determining the vulnerability of water resources and coastal management to climate change, developing adaptation options, and making periodic revisions according to monitoring results

Agriculture Sector and Food Security	**P 4.** Protecting Soil and Agricultural Biodiversity against the Impacts of Climate Change **T 4.2.** Protecting agricultural biodiversity and resources for adaptation to the impacts of climate change
Ecosystem Services, Biodiversity, and Forestry	**P 2.** Identifying and Monitoring the Impacts of Climate Change on Biodiversity and Ecosystem Services **T 2.4. to** conduct research and development activities to identify and monitor the impacts of climate change in protected areas
Natural Disaster Risk Management	**P 2.** Strengthening Response Mechanisms in Natural Disasters Related to Climate Change **T 2.3.** Continuation of training activities to raise social awareness and participation in the disaster and risk impacts of climate change.

"Republic of Turkey Climate Change Action Plan 2011-2023" (CSB, 2012b), the national vision is defined as "To be a country that has integrated climate change policies with development policies; has made energy efficiency widespread; has increased the use of clean and renewable energy resources; actively participates in the fight against climate change within the framework of its special conditions; and is able to offer high quality of life and prosperity to all its citizens with low carbon intensity." Within the framework of this vision, the objectives and targets of the climate change action plan are grouped under the headings of energy, buildings, industry, transportation, waste, agriculture, land use and forestry, cross-sectoral common issues, and adaptation.

Education and Activism

The role of education in social action has become more visible through the engagement of young people in climate activism. The reflections of climate change on formal education can best be realized through the follow-up of action processes. Raising awareness of climate change and climate action in curricula is critical in addressing climate change.

The United Nations (UN) and the 2022 IPCC report state that "education is critical in addressing climate change." Although there is a weak link between awareness of climate change and the active process of climate action according to some studies (Lorenzoni et al., 2007; Wibeck, 2014; Wolf & Moser, 2011), the most common argument in this process is that the development of an individual's cognitive level on the subject supports taking action and taking action (Neas, 2023).

Neas (2023), in his interviews with young activists in California, aimed to reveal the critical impact and active role of education in climate activism by investigating their pedagogy and activism processes toward climate change. While young people consider climate action as abstract and scientific but disconnected from everyday life, it was revealed that they acquired their cognitive

schemas on climate change mostly in formal education programs and schools. Other findings include that young people feel panic and fear about climate change.

Climate change education activities are critical to understand the effects of climate change on children's mental health and to ensure constructive participation. Trott (2021), in a study with 55 children aged between 10 and 12, examined the affective and behavioral effects of implementing a program that encourages individuals to gain awareness and take action towards climate change. After the interventions, it was observed that children developed a deep sense of respect for nature and positive attitudes. In addition, children's feelings of fear, anxiety, and sadness about climate change were alleviated by positive emotions based on climate action, and they had a sense of urgency about the need for climate action.

The fact that children and youth bring the climate crisis to the public sphere en masse and develop a visible protest process is seen as a situation that should be taken into account in terms of how the meaning attributed to activism develops over time, even if it is subject to opposition from different circles (Nissen et al., 2021).

Researchers state that regular climate action raises public awareness of environmental pollution and climate change. After Greta Thunberg's strike at the Swedish Parliament to make the Paris Agreement operational, nature and outdoor education and sustainable development education in the Swedish education system shifted towards an eco-centered approach (Kowasch et al., 2021).

Evidence shows that the reflection of the Greta Thunberg effect on education systems varies across countries. For example, Kowasch et al. (2020) showed in their study that the Greta Thurnberg effect differs in some countries. In their survey, only 12% of the students stated that Greta had a powerful impact. In addition, students' opinions vary by country. Activists in Graz, Austria, stated that Grtea was not an important reason for participation, while Portuguese students mentioned that it had a significant impact.

Researchers state that how young people make sense of the process due to the education they receive in formal education affects how they will react to climate change and shape their reactions (Pascoe et al., 2021; Napawan et al., 2017). Studies have shown that formal climate change education does not give students any insight into what can be done about climate change. However, it generates high levels of anxiety and fear. Similarly, Neass (2023) stated that formal education pedagogical processes on climate change do not support students to become climate activists and cause them to remain inactive. On the other hand, Rousell & Cutter-Mackenzie-Knowles (2019) reviewed studies investigating young people's understanding of climate change education. They found that their understanding of climate change is often limited, inaccurate, and heavily influenced by mass media. Trott (2019), on the other hand, designed a 15-week implementation process in an applied study to raise awareness about climate change among 10 and 12-year-old

students. Digital photography, hands-on training, collaborative community projects, and action processes were experienced. Children stated that they were motivated by gaining awareness about climate change, their efforts to minimize the damage to the planet, and their desire to act increased.

It is envisaged that climate action, which brings a new breath to climate change education, is an excellent context to make young people proactive if it is done under adult leadership. It is vital to understand the role of actional processes in education. Starting from the basic education level, formal climate change education plays a key role in raising awareness among young people about climate change. It will also be an increasingly mandatory subject in the curriculum in the United States and other foreign countries (Neass, 2023).

Neass (2023) sheds light on the role that climate education in formal education plays in young people's climate activism, exploring pedagogies that support the promotion of concrete actions. He observed that the educational pedagogies used for climate change in formal education generally framed climate change as an abstract and scientific issue from everyday life with an informational approach, with less emphasis on the political and justice-related dimensions of climate change. While didactic approaches to climate change education were found to be largely ineffective in influencing students' attitudes and behaviors, it was emphasized that emotion-oriented and creative approaches should be integrated into educational processes. It called for developing new forms of climate change education that engage young people in scientific, social, ethical, and political processes (Rousell & Cutter-Mackenzie-Knowles, 2019).

Monroe, Plate, Bowers, and Chaves (2019) stated that most climate education is based on knowledge acquisition in science classes. On the other hand, the concept of climate literacy works on the argument that students will take better action when they gain awareness about climate change (Dupingny-Giroux, 2018). Monroe et al. (2018) stated that in formal education, students see climate change as an abstract phenomenon that may occur in the distant future and is constantly mentioned in science education. At the same time, its impact on ecosystems and species, rather than on humans, is considered a situation that is discussed more.

Kowasch, Cruz, Reis, Gericke, & Kicker (2021), in their study, investigated the motivations of students of young activists in Austria and Portugal, the solutions proposed by young activists to combat the climate emergency, how activism can be integrated into sustainable development education, and how to develop environmental citizenship. The study results show that a sense of solidarity and collective action goals are a driving force for engaging in climate action. Young people also mention innovative and radical solutions. In particular, climate activism contributes to transferring scientific knowledge and political policy dialogues in educational processes.

In addition to the individual contributions of climate actions in education systems, it is also possible to see their effects in the social context. Reis (2020) states that climate actions in which

students participate can positively impact society, which is transformative learning processes in schools. Pedagogical transformation processes in education systems that refer to sustainable development have been articulated by Vare et al. (2019) as skill development. The fact that young people share with their families and friends after the actions they participate in the context of climate activism shows that climate education change expands its impact in the real world (Gold & Leckey, 2020).

When the international literature is evaluated in general, it is noticed that curricula focus on the processes that climate change will bring about in the future, proceed problem-centered, and intensively transfer scientific processes. The political, social, and justice aspects of climate change, the subject of climate action and the most debated issues, are among the other processes that are not addrstill need to beIn 2023, extreme precipitation in Turkey, floods and landslides due to this precipitation, extreme temperatures, forest fires due to extreme heat, etc., reveal the current state of the climate crisis. Climate change is an issue that needs to be addressed holistically from local to global, and solutions need to be developed with an interdisciplinary perspective and with the participation of all stakeholders, especially young people. The concept of literacy, which has become increasingly important in education today, aims to teach individuals to use the competencies of the relevant field in solving the problem. In this context, a basic skill to be expected from the literate new generation may be to apply what they think, that is, to act.

Activities Designed for Climate Activism

Table 9.3

Activity 1: "Local Activists"

Main Problem Statement	How can the impacts of climate change be explained through a local problem situation in a school action?
Purpose of the Event	The main purpose of this activity is for students to identify a problem they see in their environment and associate with climate change and to plan an action to draw attention to this problem situation and implement it in their schools.
Recommended Duration	4 hours + Action (2 hours) + 2 hours
Targeted Skills	Scientific process skills, Analytical thinking, Decision making, Communication, Teamwork
Targeted Values	Justice, Honesty, Patience, Respect, Love, Responsibility, Patriotism
Level	Primary School, Middle School, High School (The subject content/application of the activity can be changed and applied at different levels)

Pre-Activity Preparation Questions

1. Is there anything around you that bothers you about the environment or that you see as a problem?
2. What can you do individually about this environmental problem?
3. How can you effectively communicate this problem to others around you?

The teacher asks these and similar questions to determine the situation of the students before the activity. In line with the answers to these questions, the students start working on a problem they realize themselves or a problem situation directed by the teacher.

Activity Implementation Process

For the activity, a topic identified by the students in their environment or determined/directed by the teacher will be identified and researched in multiple ways. Afterward, an action will be planned and implemented at school in order to inform those living in the local area and draw attention to the problem. Here, educators who want to implement this activity at different levels should consider the level of students and their understanding of events. At the primary school level, students may have difficulty understanding the effects of global warming. However, they can understand situations such as extreme temperatures, precipitation, floods, erosion, etc. in the local environment. In particular, their insufficient level of readiness on the subject may make interpretation difficult. However, understanding the effects of these events and enabling them to

make an effort to explain them will enable them to express their ideas more quickly when they become adults.

The fact that students at the middle school level have relatively sufficient prior knowledge to understand the topics related to global warming more easily will facilitate the selection of the preferred topic for climate action under teacher guidance. At the high school level, it should be left to students to determine the topics and the local problem situation.

Stages of the Activity

1. Investigation of climate change and its effects on the environment.
2. Investigating the impacts of climate change on the local environment.
3. Planning an action to effectively communicate to the target audience the problem situation arising in the local environment.
4. Prepare banners, posters, poems, slogans, speeches, etc., for the action.
5. Realization of the planned action.
6. Assessment of the situation after the action and identification of recommendations for further actions.

Measurement and Evaluation

In this activity, the process can be evaluated holistically through observation before and during the activity and self-assessment after the activity.

Observation Form

Behavior to be observed	**Observation Status**		
Preparation Before Action	**No**	**Partially**	**Yes**
Research for the event			
Taking responsibility for the research and planning process			
Developing a solution for the expression of the problem situation			
Preparation for action (posters, banners, slogans, etc.)			
During Action	**No**	**Partially**	**Yes**
Realizing the planned action			
Expressing oneself correctly to the target audience in line with the purpose of the action			
Manage the action process correctly			

Self-Assessment Form

1. What did I do during the action planning phase?

……
……

2. What did I do right during the action?

……
……

3. What did I encounter during the action that I did not expect?

……
……

4. What were my shortcomings during the action?

……
……

5. What would I change if we were to plan/do the action again? Why?

……
……

6. When I evaluate the process overall, to what extent was I successful in planning and implementing the action?

……
……

Table 8.4
Activity 2: "Civil Society Organizations and Activism"

Main Problem Statement	Get to know civil society organizations fighting against climate change and follow/participate in their actions.
Purpose of the Event	The primary purpose of this event is to get to know civil society organizations fighting against climate change, to follow their actions, and, if possible, to participate in the action within the legal framework or to organize simultaneous legal action locally.
Recommended Duration	4 hours + Participation in actions or local organizing (2 hours)
Targeted Skills	Scientific process skills, Analytical thinking, Decision making, Creative thinking, Communication, Teamwork.
Targeted Values	Justice, Self-control, Respect, Love, Responsibility, Benevolence
Level	Middle and high school

Pre-Activity Preparation Questions

1. What kind of activities do civil society organizations engage in?
2. Do you know of any non-governmental organizations working on the environment?
3. Do you know of any activities by civil society organizations on climate change?
4. Do you know of civil society organizations operating in your region?

With these and similar questions, the teacher determines whether the students know about civil society organizations. If the students' awareness of this issue is weak, the teacher guides them to get to know non-governmental organizations first. If the students know, they deepen their knowledge about non-governmental organizations. In line with the answers to these questions, the process begins by directing students to research the activities and work of non-governmental organizations.

Activity Implementation Process

The activity aims that students are expected to research and get to know civil society organizations operating on climate change at local, national, and global scales in the first phase. In the second stage, the actions carried out by civil society organizations to draw attention to this issue will be examined, and legal participation will be ensured where possible. If participation is not possible, a simultaneous action will be organized in the school. It should be seen as an achievement for this activity to see what students can achieve by coming together with civil society organizations that have internalized similar problems on an issue and to ensure that they become more sensitive citizens in the face of social problems.

Stages of the Activity

1. Discussion of students' knowledge about civil society organizations.
2. Identification of civil society organizations active in climate change.
3. Researching, presenting, and introducing civil society organizations operating locally, nationally, and globally in groups.
4. Monitoring the activities and actions of civil society organizations.
5. Participation in actions where possible. When this is not possible, organize a simultaneous action locally.

Measurement and Evaluation

In this activity, a holistic evaluation can be provided with rubrics and observation forms during the activity and self-assessment and post-activity discussion after the activity.

Rubric

Student Behaviors to be Observed	**Observation Status**		
Research	**Good**	**Moderate**	**Weak**
Identifying the right sources for research			
Research on civil society organizations			
Identification and follow-up of activities/actions			
Presentation	**Good**	**Moderate**	**Weak**
Effective presentation of the prepared content			
Making the necessary preparations for the presentation on time			
Realization of the action	**Good**	**Moderate**	**Weak**
Ensuring participation in the identified actions or organizing the action locally			
Execution of the process in accordance with the purpose of the action			
Reporting	**Good**	**Moderate**	**Weak**
Presenting civil society organizations, their activities and action calendars in written form			

Observation Form

Behavior to be observed	**Observation Status**		
Preparation Before Action	**No**	**Partially**	**Yes**
Determining the action calendar of civil society			

organizations			
Preparation for participation in actions			
If the action cannot be participated in, it should be planned and carried out locally.			
During Action	**No**	**Partially**	**Yes**
Participating in or carrying out the planned action			
Expressing oneself correctly to the target audience in line with the purpose of the action			
Manage the action process correctly			

Self-Assessment Form

1. What did I do for the action process that took place in the civil society organization?

……
……

2. What did I encounter while carrying out, organizing, and implementing the action?

……
……

3. What were my shortcomings during the action?

……
……

4. What would I change if we were to plan/do the action again? Why?

……
……

5. When I evaluate the process overall, to what extent was I successful in planning and implementing the action?

……
……

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Chapter 9: Examples of Climate Change-Based Activities in the Context of Dimensions of Science and Technology Literacy

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Abstract Today, education systems are on the way to achieving their transformation to a great extent based on related field literacies and interdisciplinary literacies. Although climate change is an interdisciplinary concept, it is directly related to all science sub-disciplines and, consequently, to science and technology literacy. This section focuses on science and technology literacy, its sub-dimensions, the classification of these sub-dimensions in the context of cognition, affect, and skills, and its direct or indirect relationship with Science, Engineering, Technology, Society, and Environment. Then, examples of activities related to the key concept of climate change based on the sub-dimensions of science and technology literacy are presented.

Introduction

Today, the concept of literacy has evolved into a meaning far beyond reading and writing. In its most general definition, it can be all the things (cognitive, affective, and psychomotor) that an individual needs to know and apply in understanding and solving a problem encountered in a field. In the literature, it is seen that there are many types of literacy. Examples of these are financial literacy (Khan, Siddiqui, & Imtiaz, 2022), mathematical literacy (Çakıroğlu, Güler, Dündar, & Coşkun, 2023), assessment literacy (Deneen, & Hoo, 2023), environmental literacy (Ardoin, Bowers, & Wheaton, 2023), social media literacy (Cho, Cannon, Lopez, & Li, 2022), information literacy (Haider, & Sundin, 2022), e-health literacy (Shi, Ma, Zhang, & Chen, 2023), digital literacy (Marín, & Castaneda, 2023), agriculture literacy (Bahar, & Somuncu Demir, 2021). As can be seen, this concept, which has found a vast area in the literature and evolved into a broad meaning in the 20th century, has become a vision based on educational systems in the 21st century.

When considered based on climate change and related concepts, it is inevitable that these concepts, which are closely associated with science and technology, should be addressed in the axis of science and technology literacy. In the literature, it has been conceptualized in different ways as "science literacy, scientific literacy, science and technology literacy, and scientific and technological literacy". Technological literacy is another type that has come to the forefront, especially in the last few decades. However, the discussion will be carried out based on the context of science and technology literacy, considering that these two fields have been feeding each other since the very beginning of the known history of humanity.

Science and Technology Literacy

When Hurd (1998) looks at the historical process of this concept, which he refers to as "scientific literacy", he traces its cultural origins back five centuries and its history back more than two centuries. When we look at the use of this concept, especially in the educational context, it

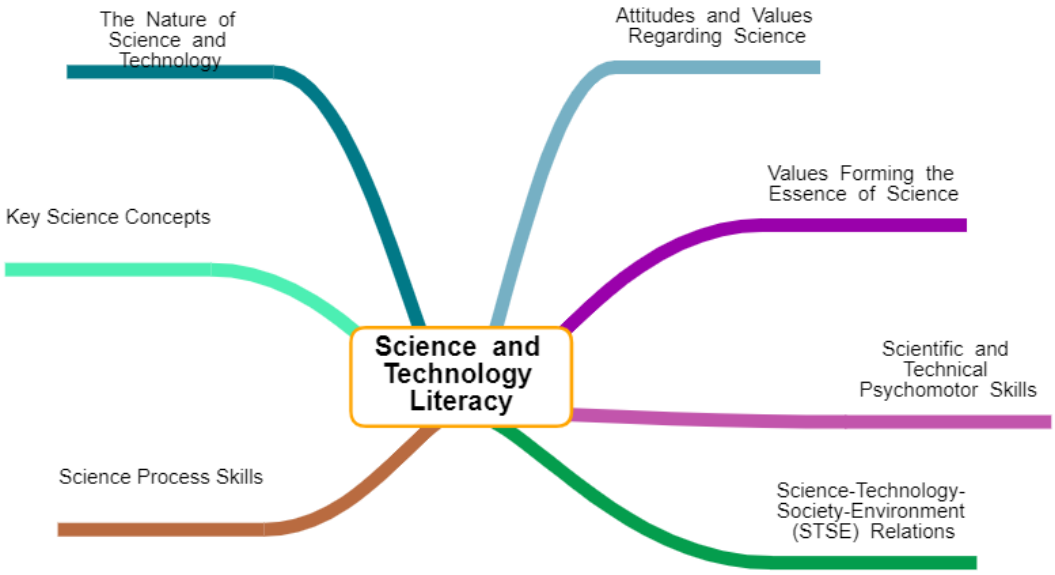
coincides with the 1950s when science education started to gain importance in the world. This period, when the space race began, drew the attention of developed and developing countries of the world to the importance of science education. In this process, especially the United States started to discuss the situation of the next generation in terms of understanding science (Hurd, 1958).

Science literacy, limited to scientific endeavors in the 1960s, has been recognized as a skill that all students should acquire since the 1970s (Hurd, 1998). Although science and technology literacy differs from other literacies' essential content, it has similar primary objectives to basic literacies. This situation can mean that the literacies addressed in education can be combined by teachers (Norris & Phillips, 2003).

When the dimensions of science and technology literacy are examined, it is seen that different dimensions are defined in the literature. Pella, O'Hearn, and Gale (1966) reviewed the studies conducted between 1946 and 1964 in the literature and found that the basic concepts in science, the nature of science, ethics that control scientists in their work, and interrelationships between science and society are among the characteristics that a science literate individual should understand. Miller (1983) defined science literacy in three dimensions: the nature of science, key scientific terms and concepts, and the effects of science and technology on society. Similarly, Bybee (1995) examined science literacy in three dimensions: knowledge of keywords and concepts, awareness of science and technological developments, and the nature of science.

The dimensions of science and technology literacy have changed since its inception. However, the basic dynamics are similar. The dimensions of science and technology literacy, directly addressed in science programs in Turkey for the first time, were most clearly defined in the 2005 science and technology program. In the 2005 science and technology program (MoNE, 2005a; 2005b), the seven dimensions recommended to be considered to raise students as science and technology literate individuals are shown in Figure 1.

Figure 9.1
Dimensions of science and technology literacy (MoNE, 2005b)



When considering the dimensions of science and technology literacy taxonomically, we can classify the above seven dimensions under the basic dimensions of cognition, affect, and skills, as seen in Table 1. The science-technology-society-environment relations (STSE) dimension represents an expansion directly or indirectly related to all components under the three primary dimensions. The fact that the achievements in all these basic dimensions and the direct or indirect associations in the axis of STSE (in the 2018 curriculum (MoNE, 2018), the engineering dimension was added and started to be considered as science-engineering-technology-society-environment (SETSE)) are exhibited in an observable way in the behaviors of the individual is an indication that literacy is realized in the behavioral dimension.

Table 9.1

Taxonomy of science and technology literacy dimensions

Cognition	Skill	Sensation
Key science concepts	Scientific and technical psychomotor skills	Values forming the essence of science
Science-related principles, terms, generalizations, laws, etc.	Scientific process skills	Attitudes and values regarding science
Learning areas	Life Skills	Attitude, motivation, responsibility Values (universal values, scientific ethics, etc.)

Science-Engineering-Technology-Society-Environment Relations

Science-engineering-technology-society-environment (SETSE) relations

Nature of science and technology, Nature of Science
Socioscientific issues
Relationship between science, engineering and technology
Science-technology relationship
Relationship between science, technology, and society
Sustainable development awareness
Science and career awareness

Climate Change as a Key Concept in the Context of Science and Technology Literacy

Climate change is one of the most popular topics in recent times. In terms of content, it can be considered a topic, a key concept, or even an interdisciplinary theme in its scope. When considered a subject or sub-discipline, it can be evaluated under environmental science. However, along with the scientific aspect of the subject, it can be considered an interdisciplinary theme that has a relationship with many disciplines, such as economic, political, geographical, agricultural, legal, social, and international relations. Although the subject is multidimensional, within the scope of this chapter, climate change is addressed in the context of key science concepts, which is a sub-dimension of science and technology literacy in the cognition dimension. For climate change to be understood correctly and placed on a meaningful ground in an interdisciplinary context, it is crucial to consider it a key concept in addressing the content on a large scale and being able to relate it. Individuals who understand climate change will be evaluated in the dimensions of skills and affect, especially when transforming them into behaviors. Within the scope of SETSE, it is a fundamental concept that directly or indirectly affects all these dimensions. When the taxonomic structure described in Table 1 is considered in the context of the educational process, it shows that content addressed in all its dimensions can have the ability to create permanent trace behavioral change in the individual, which is one of the most fundamental goals of education. In this case, it can be claimed that when climate change is addressed in the educational process and is centered as a critical concept, it can realize meaningful learning when it is processed with all its sub-dimensions.

The Place of Climate Change in Education: The Case of Turkey

Climate change is one of the basic concepts taught in courses such as Science, Social Studies, and Geography, and its relationship with different disciplines is discussed. Below is an example of an outcome of climate change at the 8th-grade level in the Science course curriculum for grades 3-8 (Ministry of National Education [MoNE], 2018).

> "**F.8.6.3.3.** Discusses the causes and possible consequences of global climate change.
> *a. The greenhouse effect is explained.*
> *b. In the context of global climate change, environmental problems' impact on the world's future and human life is questioned.*

c. Students are asked to express their predictions about the impact of environmental problems on the world's future through artistic means.
ç. Students calculate their ecological footprint (safe websites such as edu, org, and mil can be used).
d. The measures taken by the world's countries to prevent global climate change (e.g., Kyoto Protocol) are mentioned."

Although the concept of climate change is covered under different courses, the current situation shows that it is necessary to emphasize this issue in education. To this end, the **Environmental Education and Climate Change** course was added as an elective at the secondary school level in 2022 (MoNE, 2022). The fact that this course can be taken in the 6th, 7th, and 8th grades of secondary school is necessary for future decision-makers on climate change and for this target group, which will be exposed to its impact more than today's adults. Below is an example of an outcome of climate change in the Environment and Climate Change course curriculum (MoNE, 2022) (which can be taught in 6th, 7th, or 8th grades).

"**ÇEİD.4.5.** Explain the disasters caused directly or indirectly by global climate change and their effects.
a) Disasters such as floods, landslides, mucilage, fire, deforestation, drought, coastal erosion, desertification, hurricanes, tornadoes, global hunger, epidemics, etc. are mentioned.
b) Measures to be taken before a disaster are mentioned.
c) What to do during and after a disaster is discussed through an experienced disaster."

Climate Change in the Education Process and Activity Development/Implementation Processes

Climate change/crisis is among the issues that have recently emerged in education and are being addressed by most countries. The emphasis on this issue in education is among the main objectives of young people trying to shape their future and the education systems that guide them in this regard. Especially with the widespread use of new generation communication tools such as social media, young people, who can receive instant news from events not only on a local and national scale but also on a global scale, try to understand the process not only with what education offers to them but also on a broader data flow. Of course, correctly reading this large-scale data will be possible with education systems that catch up with the age. At this point, education systems must change themselves by being open to change, just as computer programs can sustain themselves by updating themselves.

Although the issue of climate change has turned into a climate crisis to the point where its effects can be felt concretely, the basis for understanding the events and phenomena depends on going through a proper education process. It is complicated for an individual who needs help understanding the basic concepts to make correct analyses and decisions in the face of intense data

flow. An individual who understands the concepts will be able to apply the process and use it in solving the problem by practicing educational activities such as a real-life simulation with a guide.

Designing activities to support learning in the educational process is very important. To design better activities in this process, teachers must follow the constantly developing and changing educational updates and be supported by processes such as guidance, mentoring, and in-service training. Concepts, principles, and processes they have yet to see during their education may be seen as more complex. In this process, projects, online pieces of training, academic studies, and books can be guiding (e.g., ClimaTePD, 2023).

The activity examples given aim to present the key concept of climate change in the axis of science and technology literacy dimensions. The activities and sample problem situations, which are explained below at different levels, constitute an example for teachers who want to implement in their classrooms, pre-service teachers who think about the key concept of climate change and want to implement it, and educators who wish to improve themselves in this subject.

Activity Examples

Table 9.1
Activity "Forests and the Future of Humans: What's in store for us?"

Purpose of the Activity	The main purpose of this activity is for students to develop a solution-oriented understanding of the problem situation/task related to forest fires and their effects. The main criteria are that this solution should be related to the dimensions of science and technology literacy, use technology correctly, and be environmentally friendly and sustainable. **Note:** In this activity, instead of focusing directly on climate change, the focus is on forest fires, one of the results of climate change that can be widely observed on a global scale due to its effects. Climate change should be emphasized, especially in the discussion of the results of the activity.
Recommended Duration	12 hours
Cognition Dimension (C)	***Key Science Concepts*** Climate change, global warming, nature, forest, living diversity, ecosystem, food web, cycles, endemic species, sustainability. (Note: Concepts can be introduced at any level, but the content and depth of the concepts should be explained, considering the differences of the target audience and group). ***Related Subdisciplines*** Biology, Environmental Science, Engineering Fields (Environment and Forestry) ***Sample Learning Outcomes (LO)**** ***** (Note: Sample learning outcomes are written to ensure that there is no deficiency in the content of the activity taxonomically on the axis of sub-dimensions while planning the process. They can be changed, decreased/or increased by taking into consideration the target audience's wishes, needs, academic level, individual differences, etc., with the level of education. A similar approach has been adopted for other taxonomic situations). ***Primary School (P)*** **LO-C.P1**. Defines the basic concepts related to forests. **LO-C.P2**. Explains the importance of forests as a natural environment for living things, the continuation of life, and our world. **LO-C.P3.** Develops solutions to protect the natural environment in forests. ***Middle School (M)*** **LO-C.M1.** Recognizes forests as an ecosystem.

	LO-C.M2. Explains the importance of forests. ***a.*** *Evaluates the importance of forests separately and together with the concepts of living diversity, ecosystem, food web, endemic species, cycles (carbon and water), and sustainability.* **LO-C.M3.** Discusses the interaction of the natural environment and humans in forests. ***a.*** *Interpret the positive and negative effects of humans on the natural environment in a holistic manner.* ***b.*** *Recognize the current and potential future problems of human activities in forests.* ***c.*** *Develops suggestions for the solution of problems that threaten forests.* **LO-C.M4.** Makes inferences about the effects of climate change on forests. ***High School (H)*** **LO-C.H1.** Recognizes the forest ecosystem. **LO-C.H1.** Explain the concepts of climate and climate change. ***a.*** *Explains the reciprocal and intricate relationship of climate change on forests.* ***b.*** *Discusses the change between climate change and forest ecosystem in all aspects.* **LO-C.H3.** Evaluates the effects of humans on forests. **LO-C.H4.** Develops creative, innovative, sustainable, sustainable and technological solutions to problems that threaten forests and strives to disseminate them. ***Higher Education (Teacher Education) (TE)*** **LO-C.TE1.** Explains climate, climate types, and climate change. **LO-C.TE2.** Discusses the relationship between the ecosystem and humans. **LO-C.TE3.** Discusses the forest as an ecosystem, as part of the biosphere of the world organism. ***a.*** *Make inferences about how changes in an ecosystem will affect the world.* ***b.*** *Discuss how changing climatic conditions affect forests and how they may affect them.* **LO-C.TE4.** Evaluates environmental problems, their possible effects, and solutions.
Skill Dimension (S)	***Scientific and Technical Psychomotor Skills*** Recognizing the materials to be used during the activity and having the ability to use them appropriately. ***Science Process Skills*** Observing, classifying, recording data, predicting, determining variables, changing and controlling variables, experimenting, interpreting data, drawing conclusions.

	Life Skills Decision making, communication, teamwork, entrepreneurship, thinking skills (analytical, critical, innovative) ***Sample Learning Outcomes (LO)*** ***Primary School (P)*** **LO-S.P1**. Makes research on forest fires. **LO-S.P2**. Decides between the solutions developed for forest fires. **LO-S.P3.** Makes teamwork in solving forest fires. ***Middle School (M)*** **LO-S.M1.** Investigates the possible causes of forest fires. **LO-S.M2.** Makes teamwork to produce solutions to forest fires. **LO-S.M3.** Develops and explains solutions for forest fires. ***High School (H)*** **LO-S.H1.** Investigates forest fires as an environmental problem. **LO-S.H2.** Collects data on forest fires and makes comments and inferences about possible new problems and solutions. **LO-S.H3.** Communicates with all stakeholders in solving forest fires and makes teamwork. **LO-S.H4.** Shares the method developed for the solution of forest fires with the relevant places and becomes a part of the solution. ***Higher Education (Teacher Education) (TE)*** **LO-S.TE1.** Researches and presents the causes of forest fires in worldwide and in Turkey and what is done to solve them. **LO-S.TE2.** Collects data on forest fires and makes comments and inferences about possible new problems and solutions. **LO-S.TE3.** Develops solutions for understanding and preventing a forest fire and makes decisions based on the criteria determined.
Affect Dimension (A)	***Values Forming the Essence of Science*** Objectivity, transparency, openness, continuous improvement. ***Attitudes and Values Regarding Science*** Developing a positive attitude towards science, giving value. ***Attitude, Motivation, Responsibility*** Developing a positive attitude towards science.

	Having intrinsic motivation to produce science and use it to solve problems. Taking responsibility for what happens around you. ***Values (Universal values, scientific ethics, etc.)*** Justice, Honesty, Patience, Respect, Love, Responsibility. ***Sample Learning Outcomes*** (Note: Although the target groups in different age groups in the affective dimension have differences in readiness and prior knowledge levels, the learning outcomes in the affective dimension are the same for this subject. Only the depth of the processing of achievements makes a difference). **LO-A.1.** Assumes responsibility for protecting forests. **LO-A.2.** He/she is willing to use science in solving the problems he/she encounters. **LO-A.3.** Acts patiently and respectfully while developing solutions for forest fires.
SETSE Relationships	***Science-Engineering-Technology-Society-Environment (SETSE) Relationships*** - ***Science, Engineering and Technology*** - ***Science-Technology Relationship*** - ***The Relationship of Science and Technology with Society*** Understand and explain the relationships between science and technology, society, environment, and engineering. ***The Nature of Science and Technology, The Nature of Science*** Scientific knowledge is factual. Imagination and creativity are essential for producing scientific knowledge. Scientific knowledge is open to change. As a human product, science is directly or indirectly affected by everything that affects human beings. ***Socioscientific Issues*** Controversial and complex issues in the interaction of science and society. ***Sustainable Development Awareness*** Sustainable development has a broad scope in different application areas, from our immediate environment to the global scale. Sustainable development awareness includes different dimensions such as long-term thinking, environmental protection, social participation, cooperation, education, and awareness. ***Science and Career Awareness*** Increasing interest in science, career opportunities, educational and professional development, environmental and social awareness, collaboration, and networking. ***Sample Learning Outcomes (LO)*** ***Primary School (P)*** **LO-SETSE.P1**. Explains the scientific processes of the events we see around us.

	LO-SETSE.P2. Understands the relationship between science and society. **LO-SETSE.P3.** Recognizes some professions in the field of SETSE**.** ***Middle School (M)*** **LO-SETSE.M1.** Discusses forest fires and their causes in the light of scientific data. **LO-SETSE.M2.** Discusses the relationship between science and society in the context of forest fires. **LO-SETSE.M3.** Cooperates in raising social awareness for sustainable solutions to forest fires. **LO-SETSE.M4.** Recognize some professions in the field of SETSE and use them for career choice**.** ***High School (H)*** **LO-SETSE.H1.** Discusses forest fires and their causes in the light of scientific data and results in a multidimensional way. **LO-SETSE.H2.** Collects data on forest fires, makes comments, and makes inferences about possible new problems and solutions. **LO-SETSE.H3.** Works as a scientist in the solution of forest fires. **LO-SETSE.H4.** Shares the method developed for the solution of forest fires with the relevant places and becomes a part of the solution. ***Higher Education (Teacher Education) (TE)*** **LO-SETSE.TE1.** Investigates the sources of forest fires in the world and Turkey and what has been done to solve them. ***a.*** *Prioritizes scientific data in the research process.* ***b.*** *Critically questions the information obtained in science-society interaction.* **LO-SETSE.TE2.** Collects data on forest fires, makes comments, and makes inferences about possible new problems and solutions. **LO-SETSE.TE3.** It aims to gain sustainable environmental awareness of the current situation, solutions, and possible future states regarding forest fires. **LO-SETSE.TE4.** Recognizes the professions related to SETSE, explains them to students, and guides students in choosing a profession**.**
Level	Primary, Middle, High School, Teacher Education (The subject content/application of the activity can be changed and applied at different levels. How it can be applied is exemplified below).

Activity Implementation Process

Mission:

"You are a forest engineer. You have been assigned to lead a team established for solving and managing forest fires in your country. You have analyzed forest fires worldwide and in your country with your team. Based on this data, you want to develop a fire detection and prevention system with the support of technology. How would you design a system to protect forests by considering technology and sustainability?"

Stages of the Activity

Primary School

1. First, to students, "What does an engineer do? What does a forest engineer do? Do you know?" questions are asked.
2. According to the answers to the questions, students are first informed about engineering.
3. After explaining the mission situation, "What is a forest? Where is it found? What do you think is its role in our environment? Which living creatures live there?", the student's readiness is tested, and their lack of knowledge is eliminated.
4. Students are asked and discussed whether they have heard any news about forest fires recently.
5. If the students have yet to hear about the recent forest fires, news about them from near to far is prepared in advance to be presented to them in a language they can understand.
6. Students are given the task text and asked to discuss it in groups.
7. After discussing the task, students are encouraged to work as a team (Note: The priority here is for students to gain awareness and take responsibility for forest fires).
8. Developed solution proposals are presented and discussed in groups.
9. Among the solution proposals discussed, the order of priority is determined to be put into practice. (Note: Here, instead of choosing first or second, the decision-making process is prioritized at the point that the projects bring better solutions. Criteria are determined together with the class under the teacher's guidance to make a decision).

Middle School

1. First, to students, "What does an engineer do? What does a forest engineer do? Do you know?" questions are asked.
2. According to the answers to the questions, students are first informed about engineering. Students are given vocational guidance.
3. After explaining the task situation, they were asked, "Where are forests found? What is the role of forests for the environment? Which living creatures live there? What are the

effects of forest fires on the environment?" the students' readiness is tested and their lack of knowledge is eliminated.

4. Students are asked and discussed whether they have heard any news about forest fires recently.
5. If the students have not heard about the recent forest fires, news about them from near to far (local and national) is prepared to be presented to them in a language that the students can understand.
6. Students are given the task text and asked to discuss it in groups.
7. After discussing the task, students are encouraged to work as a team (Note: The priority here is for students to gain awareness about forest fires, take responsibility, and develop solutions).
8. Developed solution proposals are presented and discussed in groups.
9. Among the solution proposals discussed, the order of priority is determined to be put into practice. (Note: Here, instead of choosing first or second, the decision-making process is prioritized at the point that the projects bring better solutions. Criteria are determined together with the class under the teacher's guidance to make a decision).
10. How the implementation can be sustained in the decided project process is discussed.

High School

1. First, to students, "What does an engineer do? What does a forest engineer do? Do you know?" questions are asked.
2. According to the answers to the questions, students are first informed about engineering. Students are given vocational guidance. If possible, a forest engineer can introduce his/her profession and answer students' questions. Especially in a region where there is a forest enterprise, students can take a field trip for this activity.
3. After explaining the task situation, "What is the role of forests in the ecosystem? What do forest fires change in the ecological balance?" (Note: The Mediterranean climate zone, including Turkey, is the zone with the highest number of endemic species and the highest diversity of plants and animals. For this reason, the effects of recent forest fires in this region on ecosystems and the world are emphasized).
4. Students are asked whether they have heard any news about forest fires recently and discussed. Students are given time to research related news.
5. In case the students have not heard of recent forest fires, news about the recent forest fires from near to far (local, national and global) are prepared in advance to be presented to them in a language that students can understand.
6. Students are given the task text and asked to discuss it in groups.

7. After discussing the task, students are encouraged to work as a team (Note: The emphasis here is on students taking responsibility for forest fires and developing realistic solutions).
8. Developed solution proposals are presented and discussed in groups.
9. Decisions are made to be put into practice within the solution proposals discussed. (Note: Students' decision-making processes are prioritized here. It is ensured that the criteria for making decisions are determined together with the class. The teacher is not involved in the process unless necessary).
10. How the implementation can be sustained in the decided project process is discussed. Comparisons are made with existing practices in the world and in Turkey.

Higher Education (Teacher Education)

1. First, the prospective teachers are asked questions such as "What does an engineer do? What does a forest engineer do?".
2. According to the answers to the questions, students are first informed about engineering. A forest engineer can introduce his/her profession and answer students' questions if possible. Especially in a region where there is a forest enterprise, students can take a field trip for this activity. (Note: Here, it is prioritized to gain knowledge and experience about vocational guidance for prospective teachers who will be the teachers of the new generation).
3. After explaining the task, they were asked, "What is the role of forests in the ecosystem? What do forest fires change in the ecological balance? Are environmental problems related to each other? How are climate change and environmental problems related?" (Note: The Mediterranean climate zone, including Turkey, has the highest number of endemic species and the highest diversity of plants and animals. In other words, this belt is both vulnerable to fire and rich in endemic species and living diversity. For this reason, the effects of recent forest fires in this region on ecosystems and the world are emphasized. This process is also associated with the history of science. This belt is a region where civilizations first settled, and people lived intensively. Today, a significant part of the archaeological excavation sites are also in this region. At this point, the interdisciplinary nature of different disciplines is emphasized).
4. Discuss the recent forest fires with the prospective teachers. They are given time to research the news. They are expected to research forest fires and the source of the fire. Pre-service teachers are expected to research and present the news as local, national, and global.
5. Pre-service teachers are given the task text and asked to discuss it in groups.
6. After discussing the task, it is ensured that they work as a team (Note: Here, it is prioritized that they take responsibility for forest fires, develop themselves at a level that will raise awareness among their students, and develop realistic solution proposals).

7. Developed solution proposals are presented and discussed in groups.
8. Decisions are made to be implemented within the solution proposals discussed. (Note: Decision-making processes are prioritized here. Each group is asked to determine its own criteria for decision-making. The class discusses criteria and decisions made during the decision-making process).
9. How the implementation can be sustained in the decided project process is discussed. A comparison is made with current practices worldwide and in Turkey [e.g., artificial intelligence-supported forest fire fighting (Çalkaya, 2023)]. It is discussed how vocational guidance can be provided for students who want to choose a profession in this field.
10. At the end of the activity, the following questions are discussed with the prospective teachers.
    - How can this activity be applied to an individual with different disabilities?
    - How can the activity be applied to help individuals with individual differences gain a sense of responsibility?

Measurement and Evaluation

In this activity, an analytical rubric can be used during the activity, and a holistic evaluation can be provided with self-assessment and post-activity discussion after the activity. Below are sample rubrics prepared for different levels. In addition, these forms will be more advantageous when they are prepared and applied in the web environment. For example, a web-based rubric (e.g., Google Form, etc.) can be used as an example to raise awareness among students and the environment about saving paper. In addition, when web-based, the teacher can quickly score and integrate the measurement results into the education process.

Rubric (Primary-Secondary School)

Student Behaviors to be Observed	**Observation Status**		
Solution development process	**Good**	**Moderate**	**Weak**
Cooperation with the group			
Compliance with the criteria set for the solution (proper use of technology, environmentally friendly and sustainable)			
Determining criteria in the decision-making process	**Good**	**Moderate**	**Weak**
Correctly identifying criteria for decision-making			
Realizing the decision-making process by the criteria			
Presentation	**Good**	**Moderate**	**Weak**
Presenting the developed solution proposal			

Comparison and evaluation with other proposals presented			

Rubric (High School)

Student Behaviors to be Observed	**Observation Status**		
Research	**Good**	**Moderate**	**Weak**
Identifying the right sources for research			
Investigation of forest fires and their causes			
Solution development process	**Good**	**Moderate**	**Weak**
Gathering information for a solution			
Cooperation with the group			
Compliance with the criteria set for the solution (proper use of technology, environmentally friendly and sustainable)			
Determining criteria in the decision-making process	**Good**	**Moderate**	**Weak**
Correctly identifying criteria for decision-making			
Realizing the decision-making process by the criteria			
Presentation	**Good**	**Moderate**	**Weak**
Presenting the developed solution proposal			
Comparison and evaluation with other proposals presented			

Rubric (Higher Education (Teacher Education))

Student Behaviors to be Observed	**Observation Status**		
Research	**Good**	**Moderate**	**Weak**
Identifying the suitable sources for research			
Investigation of forest fires and their causes			
Solution development process	**Good**	**Moderate**	**Weak**
Gathering information for a solution			
Cooperation with the group			
Compliance with the criteria set for the solution (proper use of technology, environmentally friendly and sustainable)			
Determining criteria in the decision-making process	**Good**	**Moderate**	**Weak**
Correctly identifying criteria for decision-making			
Realizing the decision-making process by the criteria			
Presentation	**Good**	**Moderate**	**Weak**

Presenting the developed solution proposal			
Comparison and evaluation with other proposals presented			
Adaptation	**Good**	**Moderate**	**Weak**
Updating the activity in line with the characteristics of the target audience			
Adapt the activity in line with individual differences			

Self-Assessment Form (Can be used at all levels)

6. What have I learned about climate change?

.....
.....

7. What have I learned about forest fires? How can I apply it?

.....
.....

8. What have I done to develop solutions to forest fires?

.....
.....

9. What were the points where I needed to improve in solution development?

.....
.....

10. What would I change about the solution if we were to plan it again? Why?

.....
.....

Sample Problem Situations

Activity 1: "Technology on the Side of Nature"

Main Problem: "You are a farmer. You have detected some agricultural pests in your field. As a result of your research, you found that the population of this species has increased in your region due to changing climatic conditions and that the crops in your field are among the favorite foods of these pests. How would you develop a technology-based, eco-friendly, sustainable solution to control these pests?"

Activity 2: "City 2.0"

Main Problem: "You are an urban planner. The effects of the climate crisis are becoming more palpable every day. At the same time, the number of people living in cities is increasing day by day. How would you go about building a more sustainable city that mitigates the climate crisis's effects and is technology-based?"

Activity 3: "The Best Architect of the 21st Century"

Main Problem: "You are an architect. You want to produce new designs that will reduce the effects of the climate crisis in the region where you live. For this purpose, what kind of house (or school) would you design that would not be affected by the negative effects of climate change and would be technological and carbon negative?"

Activity 4: "Engineering Wonder"

Main Problem: "You are a civil engineer. You have recently seen much flooding in your region and many of the bridges in your area have collapsed or are badly damaged. How would you develop a solution using technology to detect and quickly repair these processes?"

Activity 5: "New Generation Solar Cells"

Main Problem: "You are an electrical engineer. You are using solar energy as a sustainable energy source. However, the solar cells you use for solar energy have some common problems. You want to form a team to improve your solar cells and then take steps for widespread use. Design a solar cell that is sustainable, cost-effective and reduces the existing problems."

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