The SMILE E-Guide for Educators

Supporting Climate Change and Sustainable Mobility Education in Schools

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Smile

Introduction

The SMILE project is a KA2 Erasmus+ project in the field of school education that aims to increase awareness of climate change and sustainable mobility through the implementation of green activities in climate change education.

SMILE brings together a consortium of partners from across Europe, including the Rijksuniversiteit IT Groningen in the Netherlands, KMOP - Education and Innovation Hub in Athens, Greece, CARDET in Nicosia, Cyprus, I AND F Education and Development Ltd in Dublin, Ireland, Rightchallenge - Associação Portugal Norte Porto, and INNOVADE Li Ltd in Nicosia, Cyprus. The project, which will run for 24 months from December 2022 until November 2024.

The SMILE Erasmus+ project's main aim is to increase awareness of climate change and sustainable mobility through the creation and implementation of educational resources on these subjects. These resources along with the SMILE methodology will offer the necessary training to teachers and other education professionals so that they can feel empowered and supported whilst teaching climate change. The developed content also aims to stimulate the implementation of STEAM education as a holistic approach to teaching and learning. The interdisciplinarity of STEAM education is crucial in dealing with climate change education and behavioural changes in students toward sustainability. This educational methodology can help the further development of 21st-century skills and raise awareness and understanding of complex concepts, such as climate change and sustainable mobility. Building sustainable competencies in students, aims to transform them into agents of change for sustainable living, focusing on mobility.

 To achieve the proposed goals, the project foresees the development of an e-learning space, training curriculums for teachers, learning modules, and the development of digital breakouts and animated videos for students.

The SMILE E-GUIDE

The SMILE e-Guide was conceived to support teachers, school leaders, and other relevant educational stakeholders in their implementation of educational resources focused on climate change and sustainable mobility. The goal is to provide knowledge and resources that aid with the successful and engaging implementation of educational resources on the above-mentioned themes in the context of STEAM education. To achieve these goals, the e-guide is composed of the following resources:

- Evidence-based practical guidelines targeted to educators willing to implement activities for the purpose of climate change and STEAM education.

- Rich theoretical material to support teachers and school leaders in understanding the importance and context of climate change education and sustainable mobility.

These resources were developed by implementing focus group activities and desk research, in each partnering country, which resulted in six national reports from Netherlands, Portugal, Ireland, Greece, and Cyprus. These national reports are here compiled.

For the national reports, the consortium partners gathered their national practices regarding climate change teaching, sustainable mobility practices and incentives as well as the state of STEAM education in their countries. This resulted in an overview of the state of climate change, sustainable mobility, and STEAM education in Europe.

The e-Guide will help educators to become familiar with the importance and context of climate change education and sustainable mobility and to gain practical knowledge and inspiration from other best practices on including climate change education in their curriculum.

Additionally, this e-guide will serve as the cornerstone for the development of the rest of the SMILE activities and deliverables. Besides collecting current practices in the current educational curriculum, it also served to identify educators' needs and concerns whilst teaching these topics. The further development of the project will take these concerns into consideration, adjusting the content to be more engaging, useful, and effective and so, increasing the project's impact and sustainability.

Theoretical Background

Understanding climate change and its impacts

General Overview

Climate change refers to the long-term alteration of Earth's weather patterns at the local, regional, and global levels. The Intergovernmental Panel on Climate Change (IPCC) has stated that these changes occur due to the modification of Earth's energy budget, which can have consequences for precipitation patterns, severe weather events, and environmental systems over time. Climate change itself is natural phenomenon however, the significant contribution of anthropogenic activities has largely contributed to the unprecedent accelerated rate that this phenomenon is occurring.

The main driver of climate change is the increase of greenhouse gases in the atmosphere, such as carbon dioxide, methane, and nitrous oxide. These gases are responsible for the greenhouse effect. As the sun's rays hit the earth's surface, the earth absorbs some of that energy. The rest of the energy gets radiated back into space. Greenhouse gases are natural to the planet and help regulate the temperature. The increase in GHG concentration exacerbates the greenhouse effect, leading to a rise in Earth's global average temperature, causing global warming. Anthropogenic activities are the main cause of their release, namely the energy sector that is the main contributor, with industrial activities taking the biggest GHGs emission slice, followed by domestic use. The agricultural sector is the second largest contributor, more specifically livestock activities and crop burning. Deforestation also contributes for the release of these gases into the atmosphere. As previous stated, natural factors, such as volcanic activity and changes in solar radiation, can also contribute to climate change, but these factors are much smaller compared to human activities. Human activity as increased the greenhouse gas emissions (GHG) concentrations in the atmosphere reaching levels 50% higher, since the Industrial Revolution.

The impacts of climate change are far-reaching its effects can be felt and seen in a multitude of scenarios such as rising sea levels, increased frequency and intensity of extreme weather events, changes in precipitation patterns, and loss of biodiversity, among others. The fast change in the global weather patterns rises many problems and restrains the development of natural adaptions to the climatic conditions, putting at risk whole ecosystems and species.

From the educational sector, teachers and educational experts seem to have substantial knowledge and understanding of climate change and its impacts. There is also a consensus on the need to incorporate climate change and sustainability education in the national educational systems. It is of

extreme importance to create resources that enable teacher to teach about climate change not ad an abstract concept but as an actual and impacting global issue. Precautions need to be made due to the worldwide wave of scientific distrust and disinformation since the COVID-19 pandemic. Scientific literacy, climate change awareness and overall sustainability are all skills that the younger generation needs to develop, and the educational system need to address in their programmes.

Climate change is perceived as one of the most pressing issues facing our planet today and requires urgent action to mitigate its impacts and adapt to its effects. Despite the urgency and general knowledge on the topic, education experts recognize that the lack of proper knowledge and awareness about climate change, its causes, and its outcomes is a primary problem that leads to the undermining of this international environmental issue.

Impacts of Climate Change – National scenarios

In Cyprus

Temperature

Cyprus exhibits a temperate and dry Mediterranean climate, as indicated by the Köppen-Geiger climate classification scheme, specifically falling within the Csa and Bsh climate categories (Kottek et al., 2006). The climate varies across different regions of the island, with the plain areas being hotter and drier when compared to the mountainous areas (Table 1). The summer season, which lasts from mid-May to mid-September, is characterized by hot and dry conditions, with an abundance of cloudless days and minimal rainfall (Pantavou et al., 2020).
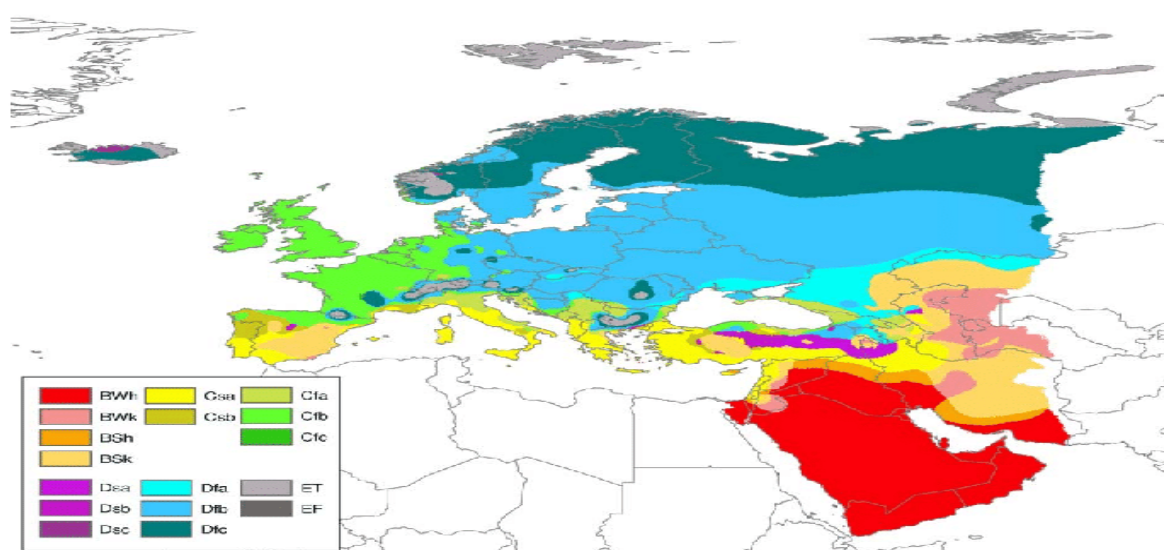
Figure 1: Köppen-Geiger climate type map of Europe (reprinted from Peel et al., 2007)

Table 1- *Overview of various climatic features of Cyprus. With increasing altitude, the temperature decreases by approximately 5 °C per kilometre. The daily temperature range between the maximum and minimum values is typically between 9 and 12 °C,* reaching 16 °C in the central plains. During July and August, the average minimum daily temperature ranges from 29 to 22 °C, respectively, across the country, while the average maximum temperature ranges from 27 to 36 °C. The highest recorded temperature on the island was 45.6 °C, observed at the Athalassa meteorological station on August 1, 2010 (DOM, 2018).

Temperature decrease with altitude	5 °C/km
Diurnal temperature range (Day -Night)	9–12 °C (reaching 16 °C in the central plain)
Maximum recorded temperature	45.6 °C (1st August 2010, Athalassa)
Mean daily temperature July–August	Plains - 29 °C Troodos - 22 °C
Mean maximum temperature July–August	Plains - 36 °C Troodos - 27 °C

Since the start of the collation of data in Nicosia, in 1892 until 2016, the mean atmospheric temperature increased 1,5°C. Meanwhile, the station in Limassol for the period of 1903 to 2016 has recorded an increase of 2,3 °C (Department of Environment, 2017). Data from the same stations in both cities describe the upward trend, with the average minimum temperature to be increasing. Although, days with temperature above 40 °C has been increasing in Nicosia, in Limassol on the other hand the highest mean temperature is showing a decrease (Department of Environment, 2017). One can assume that the reduction in hottest days is a result of an increase in Relative Humidity due to an increase in the temperature of the Mediterranean Sea, a statement that will be explored further down.

The potential future temperature patterns for Cyprus seem to indicate ongoing climatic shifts, including a noticeable increase in temperatures, a decrease in precipitation, and heightened occurrences of extreme weather events.

According to climate models, the period from 2021 to 2050 is projected to witness a rise in annual maximum temperatures ranging from 1.3 to 1.9 °C. The mountainous regions are expected to experience a more pronounced increase, reaching up to 1.9 °C. Specifically, inland areas, which are already facing prolonged drought conditions, are anticipated to see a temperature rise of 1.6 °C. Even the typically wetter and cooler western and northern regions

of the island are predicted to experience temperature increases of 1.4 °C and 1.5 °C, respectively. In comparison, the eastern region is projected to have a temperature increase of 1.3 °C.

From 2071 to 2100, the rate of temperature increase is projected to accelerate significantly, with a range of 3.0 °C to 4.2 °C. The mountainous regions will endure the greatest impact, experiencing the highest increase of 4.2 °C. Inland areas can expect a temperature increase of 3.5 °C, while the western, northern, eastern, and coastal regions are estimated to experience an increase of approximately 3 °C (Department of Environment, 2017a).

Due to notable shifts in temperature and precipitation that surpass the global average, Cyprus is recognized as a hotspot for Climate Change. The island's ecosystems are already experiencing swift transformations, and given the projected circumstances, it is imperative for Cyprus to implement its adaptation measures on a large scale in order to preserve its natural environment and support its population effectively.

Sea Level Rise

Sea level rise is one of the direct results of climate change and has significant effects on communities living along coastlines worldwide. This phenomenon is caused by global-scale processes that contribute to the ongoing rise in sea levels. The primary factor responsible for this is global warming, which leads to the melting of ice, the thermal expansion of the oceans caused by excess heat being absorbed by the ocean, and changes in the elevation of coastal land. These changes can either accelerate or reduce the submergence of low-lying coastlines (Antonioli et al., 2020).

According to the IPCC report titled "Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities," the Global Mean Sea Level (GMSL) is projected to increase by 0.43 m (with a likely range of 0.29-0.59 m), under the RCP2.6 (low GHG emissions) scenario and by 0.84 m (with a likely range of 0.61-1.10 m), under the RCP8.5 (very high GHG emissions) scenario by the year 2100 (medium confidence), in comparison to the reference period of 1986-2005. Furthermore, it is expected that sea levels will continue to rise beyond 2100, persisting for centuries due to the ongoing absorption of heat by the deep ocean and the loss of mass from the Greenland Ice Sheet (GIS) and the Antarctic Ice Sheet (AIS), and they will remain elevated for thousands of years (high confidence) (IPCC,

Reference data: ©ESRI
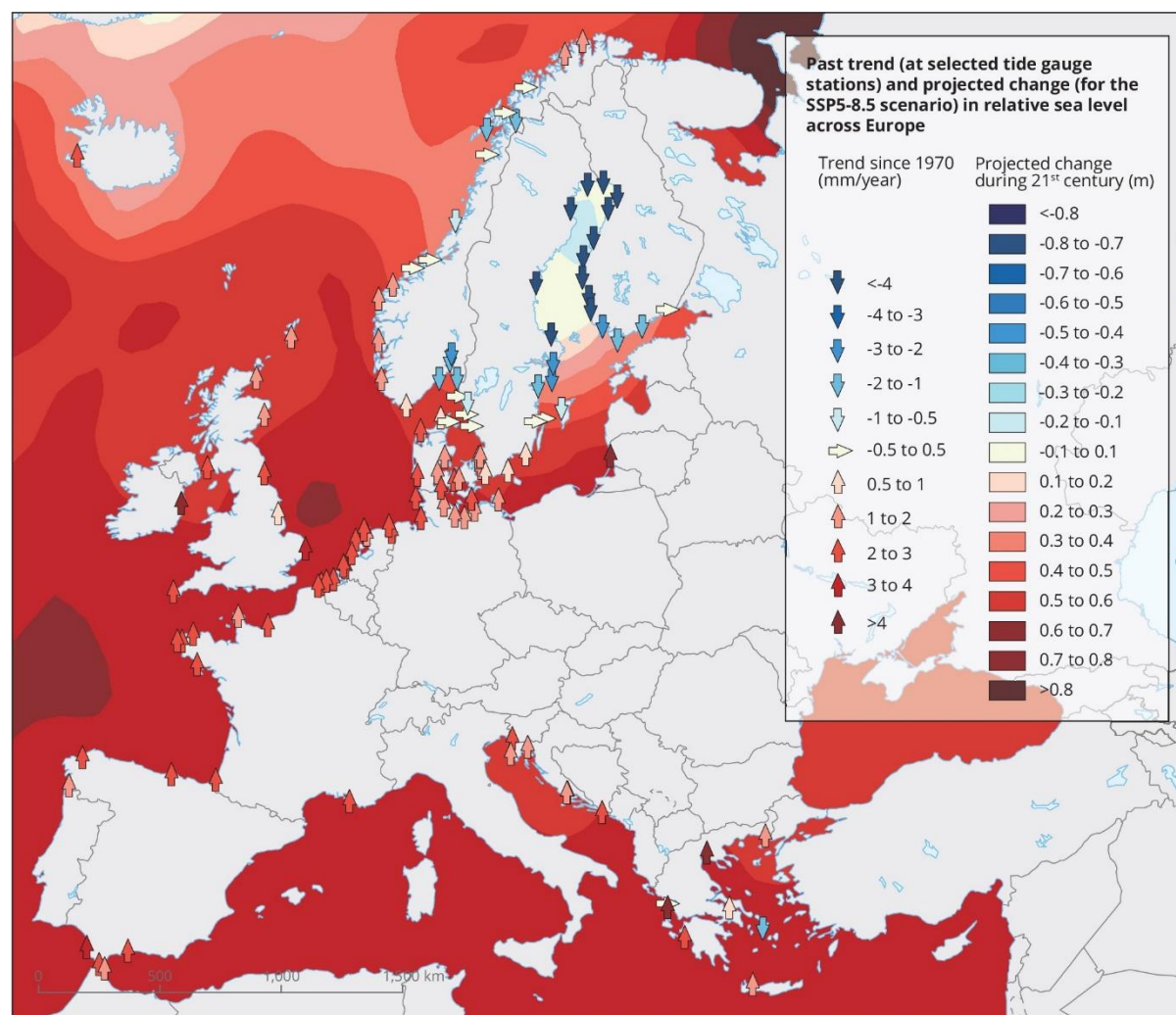
In the future, the Mediterranean Sea as well as most European coastlines relative sea-level changes are projected to be reasonably similar to the global average. As seen in Figure 2, the sea level rise in the Mediterranean since 1970 has seen an increase of 0.5 to 0.6m (European Environmental Agency, 2022).

Cyprus is already encountering coastal erosion, although is not directly connected with sea level rise but certainly is accelerating it. Since the 1950s, Cyprus has constructed 108 dams with a combined capacity of 331.951.000 m3, a significant achievement in water management that has ensured self-sufficiency in irrigation and drinking water (Water Development Department, 2017). However, freshwater retention through damming has led to a decrease in the supply of sediment to coastal areas, exacerbating erosion (Republic of Cyprus, 2006). To address this challenge, Cyprus is continuously constructing wave breakers, altering the coastal geomorphology in an effort to mitigate coastal erosion.

Elevated sea levels and decreasing underground freshwater resources from excessive groundwater extraction will cause further saltwater intrusion and further degradation of groundwater quality inland. According to the National Action Plan, coastal Sea Level Rise is considered low risk in Cyprus (Department of Environment, 2017b).

Tourism plays a vital role in Cyprus's economy, serving as the primary driving force behind its economic activities. However, since most economic operations are concentrated along the island's coastlines, they face the risks associated with Sea Level Changes. Additionally, various sectors and critical infrastructures, including the two main airports, the primary energy hub, wastewater treatment and desalination plants, seaports and Marinas and fishing shelters, may also be affected by rising sea levels.

Precipitation

Cyprus has experienced a consistent decline in precipitation since the early 1900s. The recorded data reveals a reduction of approximately 17% in precipitation during the period from 1971 to 2000 (463 mm) compared to the initial data period of 1901 to 1930 (559 mm).

Climate models simulate precipitation patterns for the period of 2021 to 2050, indicating a relatively small decrease of 10 to 20 mm in average annual rainfall. This reduction is primarily observed in the mountainous regions. However, the most significant shift in precipitation is anticipated between 2071 and 2100. During this period, the average yearly rainfall is projected to decrease by 100 to 130 mm in the mountainous and western regions, particularly in the Akamas peninsula. The northern areas of the island may experience a reduction in the range of 90 to 100 mm. In contrast, the eastern part of the island and inland regions are expected to see a relatively smaller decrease of less than 50 mm (Department of Environment, 2017a).

Extreme Events

Extended periods of drought and elevated temperatures are frequent occurrences in Cyprus. When Cyprus experiences prolonged periods of drought, particularly when they occur in consecutive years, the consequences can be devastating for its population, wildlife, and vegetation. The year 2008 stands out as one of the most severe periods for the population, with the average annual rainfall for the hydrological year 2007-2008 reaching only 272mm. This made it the second-worst year since 1901 (DOM, 2019). The agricultural sector suffered significant crop failures due to major water cuts, and even municipal water supplies were reduced for domestic use. In response, the Cyprus Government implemented an action plan and sought assistance from the European Solidarity Fund for the first time to address this challenge. A grant of 7.6 million euros was awarded, leading to the transportation of drinking

water tankers from Greece. To facilitate this large-scale water transportation, Cyprus constructed an anchorage and a 1.1km pipeline to connect to the Limassol water supply facilities. The 2008 action plan encompassed various measures, notably paving the way for the development of major desalination facilities that have since ensured the independence of the drinking water infrastructure from climate conditions (Water Development Department, 2008).

The extended periods of drought and more frequent elevated temperatures, create a heightened susceptibility to forest fires. The Cyprus Forest Department reports that in 2020, there were 108 recorded forest fire incidents, and in 2021, there were 111 incidents. While the number of outbreaks remains relatively consistent, the extent of the burned area experienced a significant difference. In 2020, the burned area encompassed 1,305 hectares, whereas, in 2021, it expanded to 6,612 hectares. Out of the identified outbreaks, which account for 88% of the total, 85% are attributed to human activities, while only 15% are caused by natural factors such as lightning (Forestry Department, 2021).

Climate change: National challenges and strategies

The responsible authority for documenting climate change impacts and drafting the National Adaptation Strategy (NAS) in Cyprus is the Department of Environment of the Ministry of Agriculture, Rural Development and Environment (MARDE). Cyprus' national strategy is documented in the "National Strategy on Adaptation to Climate Change" report of 2017. The National Adaptation Strategy to Climate Change was passed into legislation with Ministerial approval Number 82.855. The document is accompanied by the National Adaptation Plan (NAP) "Climate Change Action Plan" which defines each sector's risks with the adaption actions and the responsible authority for implementing the actions and monitoring system. Both documents are based on the contract 22/2014 of the Ministry of Agriculture "Climate Change Risk Assessment" report that was submitted in 2016 (Department of Environment, 2023).

The Department of Environment is focusing on the following eleven sectors: water resources, soils, coastal zones, biodiversity, agriculture, forests, fisheries, public health, energy, tourism, infrastructure.

As previously mentioned, Cyprus is recognized as a "hotspot" for climate change, experiencing more pronounced changes compared to other regions, despite its negligible contribution to global greenhouse gas emissions. The country has been monitoring and continuously adapting its critical infrastructure to address climate change risks. This requires substantial economic investment not only to meet the growing needs of its population but also to accommodate the millions of tourists who visit Cyprus annually. In 2019, tourism arrivals reached a peak of 3.5

million (Cyprus Statistical Services, 2021), which exceeds the population of the Cyprus government by more than 3.5 times.

Ongoing development, particularly in coastal regions, presents additional challenges such as the loss of habitat, biodiversity, and critical ecosystems. These factors contribute to increased vulnerability to climate change for both the natural world and societies. Urban expansion in Cyprus continues to grow, leading to intensified urban sprawl. Consequently, urban areas in Cyprus suffer from significant Urban Heat Island effects and are prone to flooding due to insufficient vegetation, lack of green spaces, and soil sealing. The amount of green space per inhabitant in Nicosia is between 10 to 20 m2 and for Limassol it is less than 5 m2 (EEA, 2020). Local authorities in Cyprus face financial constraints that hinder their ability to implement adequate measures. The Planning Department and the Environmental Department do not prioritize addressing this matter, as it is not within their current focus.

The intensification of desertification, soil erosion, and the decline of ecosystem services continues due to the persistence of unchanged agricultural practices. There is limited recognition among farmers regarding the challenges posed by climate change, as land use decisions are predominantly driven by profit rather than environmental considerations. The absence of stringent policies aimed at mitigating these issues can be attributed to resistance from farmers and insufficient economic incentives provided by the government.

Planning zones undergo frequent shifts without proper monitoring of their environmental impact. There is minimal consideration given to changes in land use, particularly when agricultural land is converted into residential areas, leaving little remaining uncovered land for green spaces. The elevation and geology of an area, which can offer nature-based solutions for mitigating climate change and promoting ecosystem services, are not taken into account. Green spaces are fragmented, and the concept of green belts is absent. Green belts have the potential to create specific microclimates that can contribute to addressing urban atmospheric challenges. Additionally, they can serve recreational purposes for residents and provide a sanctuary for wildlife.

The Department of Environment for the purpose of drafting the 2017 National Strategy commissioned 5 actions, targeting the most urgent impacts of Climate Change (Department of Environment, 2023):

1. The national action plan combating desertification (Department of Environment)

2. The future of agriculture in Cyprus (Department of Environment)

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3. Experimental Investigation of the impact of reduced irrigation, increased sun exposure and temperature on specific crops (Agricultural Research Institute)

4. Climate change forest impact assessment (Forestry Department)

5. Plan to remove the dependency on rainfall levels for the needs of drinking water (Water Development Department)

Additional challenges emerge due to the division of the island between two communities, resulting in isolated and fragmented efforts within each community. While some bi-communal projects exist that assess biodiversity in both communities and within the buffer zone, like the IPSI project "Cyprus Buffer Zone as a Socio-Ecological Landscape" (IPSI, 2014), the current political situation poses significant obstacles to developing a comprehensive strategic plan for the entire island.

Climate change - Greece

Temperature

In Greece, it has been estimated that the annual mean temperature has been slowly increasing since the 1960s and will continue to do so throughout the end of the century. According to the International Energy Agency, Greece has surpassed the world average rate of warming in the last two decades, which has been estimated at 0.03 Celsius per year. In contrast to the world average, in Greece, the level of warming between 2000 and 2020 has been calculated at 0.05 Celsius per year (IEA, 2022), which depicts an alarming increase in mean temperature in the country.

Temperatures are expected to rise even more by the end of the century, which will be more noticeable during summer and autumn and less during spring. At the same time, periods of hot extremes have been elongated, especially in the eastern Mediterranean. Heat waves are expected to increase and lengthen in duration, not only during the summer but on an annual basis as well (Climate Change Post, n.d.). The increase in heat waves is not expected to be accompanied by cooling waves during the winter, which are expected to decrease in number. It has been estimated also that by 2050, Greece is going to be hit by heat waves for 15 to 20 days per year (Georgakopoulos, 2021).

The annual increase in temperature is shown to result in significant risks when it comes to energy supply. In specific, rapid rises in the levels of warming can impact the efficiency of thermal power plants, which could affect the electricity supply in Greece. While the temperature increases creating heat waves, the demand for electricity grows as well. Escalated power demand can result in many problems such as power outages (IEA, 2022). A similar event took place in June of 2017 when the

extreme heatwave of 44 degrees Celsius resulted in a power outage. The power outage affected various Greek regions in the west and north suburbs.

Sea level

Another implication of rapidly rising temperatures is of course the rising water levels. The sea level in Greece is expected to continue to rise up to 2 meters until 2100 (IEA, 2022). If the shoreline retreats at such a pace, then numerous Greek coastal areas are going to experience critical issues such as the decline of social and economic activities and especially tourism, which plays a key role in Greece's economy. At the same time, coastal erosion is going to be a grave problem for low-lying areas, as it can cause severe floods (Harris-Papaioannou, 2021). Not only that, but at the same time the energy infrastructure, which is mostly located in coastal areas in Greece, is going to be facing technical and structural issues.

Precipitation

According to scientific estimations, rainfall trends have been mostly negative with a decrease of 10% to 20% during the 20th century (IEA, 2022). Rainfall levels are expected to drop even more. This is interpreted as long periods of hot weather, severe droughts and unavailability of water resources, degradation of soil in terms of soil fertility and moisture, and overall extended dry spells (Georgakopoulos, 2021).

The decrease in precipitation also results in higher risks of fire and flood at the same time. On one hand, less frequent rainfalls in combination with higher temperatures have led to extended periods of droughts and more heatwaves, especially during the summer when the temperatures in Greece are at their peak. Extreme droughts and strong winds lead to a higher possibility of fires. Greece has suffered many wildfires, in fact, while being unable to control some of them, has led to a grave loss of human lives. For example, during the summer of 2022, there have been approximately seven wildfires only between the months of June and July (Friedman, 2022). On the other hand, if there is an occurrence of extreme rainfall, following severe dry spells, there is a higher risk of floods as well. That is because wildlife and flora have been dried out and the soil has been compacted, thus it cannot absorb the rainfall, which accumulates on the surface, leading to floods.

Extreme events

High temperatures, elongated dry spells, decreased rainfalls and soil erosion have all contributed to the appearance of extreme weather phenomena and natural disasters in Greece. Natural disasters that take place in Greece most frequently are earthquakes, flash floods and fires. All those natural phenomena, except earthquakes, seem to increase in frequency, due to climate change, and impose not only serious economic burdens but also result in human suffering and loss. An example of the

latest most gruesome natural disaster happened in Mati, Athens in 2018, during the worst heatwave that has hit Greece so far, 102 people were lost in the fires (Oghanna, 2021), while many more suffered serious health problems.

Climate change: National challenges and strategies

In Greece, the Ministry of Environment and Energy has developed a **National Climate Change Adaptation Strategy (NAS),** which was endorsed by the Greek Parliament in 2016 (IEA, 2022). NAS clarifies the general targets, the driving principles, and the necessary tools for the implementation of a modern and effective strategy with the purpose of adapting to environmental policies and being in accordance with the United Nations and EU environmental laws (Greek Ministry of Environment and Energy et al., 2016). The Strategy's aim is to create the necessary information base and draw the guidelines in order for the responsible national agencies and instruments to adopt a new environmental framework and be able to counter the menaces and exploit opportunities that arise from climate change.

The National Adaptation Strategy itself does not provide an in-depth analysis of the indispensable sector-specific policies that need to be adopted, but it rather provides a SWOT analysis and a general framework for their implementation. This is why the **Regional Adaptation Action Plans (RAAPs)** have been developed. RAAPs include a detailed analysis and determination of the purposes, adaptation actions and policies, and the different adaptation priorities that should be set at the regional level (Greek Ministry of Environment and Energy et al., 2016). Thus, they include climate change impact assessments and region-specific actions according to the different needs and opportunities in every region (IEA, 2022). The National Adaptation Strategy and the thirteen RAAPs that have been developed discuss topics such as:

1. Weather and Climate issues,

2. Extreme weather events,

3. Agriculture and stockbreeding,

4. Forestry,

5. Biodiversity and ecosystems,

6. Coastal zones,

7. Water Resources,

8. Fisheries,

9. Energy,

10. Infrastructure,

11. Transport,

12. Health,

13. Cultural Heritage etc.

The Greek NAS and the 13 RAAPs are supported with human and financial resources (an overall budget of 14.2 million euros) by the **EU LIFE Programme**, which is a funding mechanism for the environment and climate change. In this context, the project "**LIFE-IP AdaptInGR** – Boosting the implementation of adaptation policy across Greece" was developed. This project aims to provide the necessary support in order to guide Greece's implementation of adaptation measures to climate change. For this purpose, the project will provide evaluation and monitoring mechanisms, mobilize public authorities and disseminate good practices between other EU countries (Adaptivegreece, 2016).

At the same time, in 2022 Greece adopted a new law called **"National Climate Law"**, which was also published in the Press of the Government of the Hellenic Republic. The National Climate Law seeks to create the framework for Greece's road towards climate change adaptation and climate neutrality until 2050, creating a more environmentally sustainable, socially just and greener place to live (Newspaper of the Government of the Hellenic Republic, 2022). Although, the law has been severely criticized by the public as not being enough to guarantee climate neutrality for Greece. In specific, on one hand, civil society has characterized the law as not setting high enough objectives that are in accordance with the international environmental target of reducing climate change to 1.5 Celsius. On the other hand, the law seems to repeat targets and objectives that have already been put into effect by previous legislations (Greenpeace, 2022).

The road toward climate neutrality has been proven to be turbulent in Greece, as much as in other countries. Many challenges have arisen that have obstructed the process of combatting climate change, which have to do mostly with political and economic profits. More specifically, the fight against climate change requires not only national dedication through legislation and practical action but also strong economic commitments and expenditures. In Greece's case, there is a combination of economic incapability of pursuing costly policies and also an inefficacy and a lack of the appropriate technology, equipment and infrastructure, especially in remote regions or islands.

Climate change – Ireland

Ireland is experiencing a number of impacts from climate change.

Temperature

Ireland is experiencing a warming trend, with average temperatures increasing by around 0.7°C over the last century. Heatwaves are becoming more frequent, and the number of frost days is decreasing. The warmest year on record for Ireland was 2018, with an average temperature of 10.8°C.

Precipitation

Ireland is experiencing more extreme weather events, including heavy rainfall, flooding, and droughts. The amount of precipitation in Ireland has increased by around 5-10% over the past century, and the frequency of heavy rainfalls has increased. This has led to an increase in river and coastal flooding, with several severe floods occurring in recent years.

Sea level

Sea levels around Ireland are rising, which is increasing the risk of coastal flooding and erosion. The rate of sea-level rise in Ireland has been around 2.2mm per year since 1993, which is slightly higher than the global average.

Extreme events

Ireland is also experiencing an increase in the frequency and severity of natural disasters such as storms, wildfires, and droughts. Storms such as Storm Ophelia in 2017 and Storm Desmond in 2015 caused significant damage and disruption, and wildfires have become more common in recent years.

These impacts of climate change are having significant social, economic and environmental consequences in Ireland. For example, flooding can cause damage to homes, businesses and infrastructure, and also impact agriculture and the environment. Rising sea levels also threaten coastal communities and infrastructure and have implications for shipping and tourism. It is essential that effective measures are taken to mitigate and adapt to these impacts, including reducing greenhouse gas emissions, improving infrastructure, and developing effective policies and strategies to address the challenges of climate change.

Climate change: National challenges and strategies

Despite the urgent need to adapt and make the country more resilient to climate change, there are several challenges at the economic, political, and social level.

For the implementation of climate policies, there is a concern that this may have negative economic consequences, particularly for the agriculture and transport sectors. There is a need for a just transition to a low-carbon economy to ensure that the transition is equitable and does not disproportionately affect certain communities or groups.

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At the political level, there is a need for cross-party support and long-term political commitment to address climate change. Climate policies may be affected by changes in government or shifts in political priorities.

Lastly, public awareness and engagement are key to addressing climate change. There is a need to increase awareness and understanding of the issue, and to encourage individuals to take action to reduce their carbon footprint. However, changing individual behaviour can be challenging, and there may be resistance to change in some communities or sectors.

Despite these challenges, the Irish government is taking action to fight climate change. In 2019, the Irish government launched a Climate Action Plan, which sets out over 180 actions to address climate change across all sectors of the economy. The plan includes targets to achieve net-zero emissions by 2050, and to reduce greenhouse gas emissions by 7% per year on average from 2021 to 2030.

To achieve a low-carbon energy sector, Ireland is increasing its use of renewable energy sources, particularly wind power. The country has set a target to generate 70% of its electricity from renewable sources by 2030 and has introduced a number of policies and incentives to encourage the development of renewable energy. Complementary, to promote sustainable mobility and reduce the GHG emissions for the transportation sector, Ireland is promoting the uptake of electric vehicles through a range of incentives, including grants for purchasing electric vehicles and installing charging points. The government has set a target of having 936,000 electric vehicles on Irish roads by 2030.

Climate Change – Netherlands

Currently, several impacts in the Netherlands are observed from climate change phenomena.

Temperature

The Royal Netherlands Meteorological Institute (KNMI) reports that the temperature in the Netherlands has been increasing at a faster rate than the global average. Between 1901 and 2020, the annual mean temperature in the Netherlands rose by 2.3°C (IEA, 2022).

Precipitation

Sea Level

The Dutch coast has witnessed a sea level rise of approximately 20 cm per century with the resulting projections for 2100 to range up to about 2 meters. This rise is attributed to climate change factors such as the melting of land ice and glaciers, the thermal expansion of seawater due to rising temperatures, and land subsidence (Magnan et al., 2022).

Extreme events

The Netherlands is prone to extreme weather events, including heavy rainfall and flooding. Due to global warming, the air in the Netherlands will contain more water vapour, about 4-5 percent more per degree of warming. Due to this, there is an increasing trend in average annual precipitation, leading to more frequent and intense rainfall events. Precipitation extremes have increased in the Netherlands in most statistics. Due to the whimsical nature of the weather phenomena that cause these extremes, these increases cannot always be determined statistically with certainty, especially for the heaviest showers. Due to global warming and the associated increase in the amount of moisture, a further intensification of precipitation is expected (KNMI, 2018; Abiodum et al., 2017).

Climate change: National challenges and strategies

Besides the above mentioned impacts, climate change directly and indirectly affects biodiversity in the Netherlands. Factors such as eutrophication, rising temperatures, floods and altered weather patterns such as extreme precipitation contribute to habitat loss and fragmentation, resulting in a decline in species diversity and abundance (Verschuuren, 2019). This phenomenon is also present around the globe.

The Netherlands is facing several challenges in addressing climate change, including economic, social, and political obstacles. An important challenge that the Netherlands face is the transition to a low-carbon economy. This will require significant investments in renewable energy, sustainable transportation, and other low-carbon technologies however, the cost of these investments can be high. Another obstacle arises from the social debates regarding the low-carbon economy and public opinion. While there is broad public support for climate action in the Netherlands, there is also resistance from some groups who fear that the transition to a low-carbon economy will harm the economy or their livelihoods. Finally, the mitigation of carbon emissions derive from agriculture arises significant obstacles. Agriculture is a significant source of greenhouse gas emissions in the Netherlands, and reducing emissions from this sector will be challenging. Many farmers are resistant to change, and there may be tensions between environmental goals and economic priorities (Climate Policy, 2020).

According to Dutch official governmental resources (Climate Policy, 2020), Dutch climate policy focuses on mitigation by reducing greenhouse gas emissions to prevent the rapid and radical evolution of climate change. Parallel to reducing greenhouse gasses, the government takes measures to adapt to the impacts of climate change. For instance, by taking measures to prevent flooding and protect freshwater supplies, reinforce dikes and dunes, and to manage heat stress in cities by planting more vegetation. Some examples of those measures are increasing the height of dykes and expanding the

capacity of pumping stations and beach nourishment to maintain the level of sand along the coast. Spatial planning measures include the preparation of flood storage areas.

In the energy sector, several measures are also being taken to make the transition towards a low-carbon sector. One of those proposed measures, involves the enhancement of energy efficiency in 1.5 million residential homes, which is expected to reduce 1 megaton of carbon dioxide emissions from utility buildings. Another one is the ban of natural gas as a heating source, new buildings, and existing structures will necessitate improvements to facilitate the adoption of heating methods that do not rely on fossil fuels. Municipalities will play a pivotal role in adopting a localized and participatory approach to achieve carbon neutrality in housing, by making each neighbourhood's housing stock carbon-free in a step-by-step manner. To the sector transition even further, the energy tax system shall be enhanced through the provision of more robust incentives to promote energy efficiency and reduce CO2 emissions.

In terms of mobility, by 2030, all new passenger cars are mandated to be emission-free, with incentives for electric vehicles being provided through several taxation measures, including support for the used car market. Additionally, 1.8 million charging points are planned to be installed by 2030 to facilitate the transition. There will also be promoted a modal shift from cars to bicycles and public transport, with smart solutions being implemented to enable logistics to organize more efficient and sustainable transport.

Climate change – Portugal

Temperature

Portugal has mostly a Mediterranean type of climate. This translates into warm and dry summers and cool and wet winters.

In 2019, during the European Council, President von der Leyen stated that "Portugal is one of the countries most affected by climate change". Portugal fits, in most of its territory, in the Mediterranean-type climate characterized by warm and dry summers and cool and wet winters (Carvalho et. al., 2014; Schleussner et. al., 2019). Like the rest of the Mediterranean countries in the south of Europe, Portugal is experiencing a rise in temperatures and the frequency of extreme events. In the worst-case scenario prediction model (RCP8.5), by 2100 temperatures will rise 8°C in Portugal whilst globally will increase by an average of 4.3°C. Between 1976-2006, the average temperature increased by 0.52 ◦ C per decade which is more than double the rate of the mean annual global temperature increase (Schleussner et. al., 2019).

Precipitation

In terms of precipitation (scenario RCP6.0 - global warming reaches about 3°C by 2100), Portugal will face a decrease of around 30% in the southern regions and 15% in the northern ones. These values, truly exemplify the climate issues that the country faces (Schleussner et. al., 2019). The country is facing and overall drying trend, except for the northeastern section of the territory that will have an increase in winter total precipitation (Ana Cristina Costa et al., 2011; Jacinto et al., 2015).

The rainfall patterns changes will also result in an increase of extreme rain events however, since the dry spells with be more severe and lengthy, the compacted and dry soil loses the ability to retain moisture. The water that accumulates on the surface causes floods and landslides. These extreme rain events, due to the soil compaction, also have little impact in replenishing the freshwater groundwater resources (Ana Cristina Costa et al., 2011; Jacinto et al., 2015). Freshwater shortage is becoming a more reoccurring problem in Portugal.

Sea Level

Portugal has a large coast, being one of the most affected coastlines worldwide by the erosion phenomenon. The problem takes another dimension when we are confronted by the fact that 75% of the inhabitants live in coastal municipalities (Marinho et. al., 2019). Coastal erosion is already significant in 67% of the continental shoreline due to sea level rise (Schleussner et. al., 2019). This coastal erosion present itself not only as a hazard for human lives that live near the shore but for coastal ecosystems as well. Estuaries and will. Transitional ecosystems, like estuaries and coastal lagoons tend to be biodiversity hubs and nurseries for fishes and other marine animals, these will be the most affected by the sea water intrusion (Ferreira et al., 2008).

Extreme events

Heatwaves and wildfires frequency and intensity have increased due to temperatures rise and subsequent drought that the country faces. In relation to other Mediterranean countries, Portugal is the country that has suffered by far the most from forest fires. During the last 30 years, 35% of the Mediterranean region's fire incidents and 39% of the area affected each year were located in Portugal (Schleussner et. al., 2019). In 2017, around 70 thousand hectares of land were lost due to wildfires. One particular event, the great fire of "Pedrogão Grande" was responsible for 53 hectares on land burned and 64 deaths (ANPC, 2017). The rising temperatures, wildfires, lack of strategies natural resources management have aggravated the drought scenario, that currently affects 90% of the continental territory. In some regions desertification events are also taking place. Predictions state that this scenario will aggravate even more in the future (Reuters, 2023).

On the opposite side, extreme rains during winter months have led to flood events that are becoming more common. Extreme droughts and asphalting leads to soil impermeabilization, which leads to floods and landslides. In December 2022 in capital city Lisbon, rained in two days around 15% of all annual precipitation- this was the broke the record for rain fallen in one hour. This is due not only to climate change but also for lack of proper management policies and adequate drainage infrastructures (Ferreira, 2022).

Climate change: National challenges and strategies

All this climate changes consequences are having severe socio-economic impacts. In the agricultural sector is responsible for yield gaps and the increased need for irrigation. The fishing sector is also being affected due to changes as well as overall labour safety and productivity due to temperatures increase (Schleussner et. al., 2019).

An example of actions implemented to tackle climate change and promote sustainable development is the "Portugal 2020" programme. This programme was implemented in Portugal during the 2014–2020 and was funded by the European Union (EU) Cohesion Policy in Portugal. Medeiros (2020) analysed the progress of such programme using a five-dimensional concept of sustainable territorial development, which includes supporting a circular economy, social environmental awareness, environmental conservation, global governance sustainability, and global spatial planning sustainability. The analysis of executed projects until September 2019 reveals that the initial goal of allocating 25% of the funds to sustainable development has fallen short, with only 14% being allocated. The lack of a strategic vision for sustainable territorial development in Portugal is highlighted, as the project selection does not follow an overall strategic development vision for the country. Instead, the approved projects tend to focus on local or regional interests, which may not contribute significantly to the overall and sustainable development of the country. At the same time, the municipalities play a crucial role in developing and implementing mitigation and adaptation solutions due to the local and context-specific nature of climate impacts. However, a survey-like study, in 308 municipalities across the country where 109 valid answers were obtained, revealed that climate change is still considered "little" or "not important" in planning agendas. There is also a noticeable difference in the drivers and concerns related to climate policy and action between the Littoral (coastal) and Inland regions of Portugal. The Littoral prioritized actions related to 'plans, alert systems and risks' (52.9%), as well as 'sustainable urban mobility' (52.9%); while Inland regions emphasized actions related to 'efficient management of municipal buildings' (59.5%) and 'efficient public lighting' (48.2%) (Campos et. al., 2017). However, littoral municipalities' efforts still seem insufficient due to the country's high risk of flooding and coastal erosion. Governmental responses and management are proving inadequate. Interviews with key actors in coastal planning in Portugal, the lack of policy clarity

and political will, the weak science and poor coordination of stakeholders' participation (Schmidt, 2013).

Environmental policies in Portugal seem to focus more on problem mitigation rather than adaptation efforts overall (Campos et. al., 2017), perpetuating the environmental challenges that fustigate the country. Campos et. al. (2017) emphasized the need for capacity building, addressed the issue of equity, highlights the role of European networks, and underscored the relevance of cultural differences between Littoral and Inland regions.

Despite these challenges, the Portugal 2020 program has supported projects aimed at building social environmental awareness and promoting environmental conservation, which have been implemented effectively and consistently across the country. However, some aspects, such as the support for solar energy exploration in urban areas and the implementation of a circular economy, have been limited. It lacks a clear strategic vision that addresses crucial components like a circular economy strategy and urban sustainability (Medeiros, 2020).

One noteworthy result is the support for the modernization of the national railway system, which accounted for 15% of the sustainability and resource efficiency funding. This investment has sparked a debate, as some argue that it is a more sustainable form of transport infrastructure compared to excessive road and highway building in previous EU Cohesion Policy periods. However, the investments in the railway system primarily focused on improving existing connections rather than building new ones, and the replacement of old railway rolling stock with energy-efficient alternatives was not adequately supported (Medeiros, 2020).

Sustainable mobility and its connection to climate change

The sector with the highest global greenhouse gases (GHGs) emissions is indubitably the energy sector, with 73.2% of the total emissions in 2020 according to "Our World Data" (Ritchie & Roser, 2023). In the European Union (EU), transportation represents one quarter (25%) of the GHGs emissions. Road transportation in particular accounts for 71% of the transportation sector emissions on the EU (UNECE, 2023). These statistics define, in a clear manner, the crucial need to transform the transportation to become more sustainable and so, lower on emissions. Indeed, this transformation has been a great priority of the European Union (EU), being linked to the achievement of the Sustainable Development Goals (SGDs) and the transition to a net-zero economy (Nations, 2021). The EU has been funding innovative programmes to push sustainable mobility and smart connectivity forward, such as the "Fit for 55". But what is sustainable mobility and smart connectivity?

Sustainable mobility can be defined has the transportation of people and goods in an efficient, safe, accessible, and affordable way (Nations, 2021). It focuses mostly on the transportation method

adopted. On the other hand, smart connectivity focuses more in improving the trading processes. This encompasses the associated policy of trading, infrastructure, and global trading processes such as supply, demand, transport, and logistics. Smart connectivity aims to boost global economy whilst saves resources by developing more efficient processes and systems (Nations, 2021).

In EU, sustainable mobility can be prioritised at an individual/citizen level by choosing fewer polluting ways of transportation.

In Cyprus

In Cyprus, the primary mode of transportation is predominantly reliant on passenger cars. Over the past 30 years, urban sprawl has significantly intensified, leading to the development of cities without adequately integrating sustainable transport principles into the planning and design processes. As of 2022, Cyprus holds one of the highest rates of passenger car usage in Europe, with 655 cars per 1000 inhabitants (Eurostat, 2023). In an attempt to address the congestion and pollution issues that have accumulated over the past decades, the focus has mainly been on expanding the road system within cities and suburbs to accommodate more cars. However, only in recent years have initiatives started emerging to adopt a new approach. In 2010, the first Integrated Mobility Master Plan (IMMP) was completed for Nicosia City, aiming to promote sustainable mobility practices.

In 2011, the Ministry of Communication and Works in Cyprus released the Sustainable Transport Guidelines, which outline the approach to developing and executing initiatives in a responsible and sustainable manner. These guidelines prioritize considering all users' needs while ensuring that schemes are formulated and implemented responsibly.

Their objective is to ensure that the principles of sustainable transport are thoroughly integrated into the design process, as well as the existing environmental assessment processes and procedures. It is important to highlight that these guidelines are aimed at all professionals involved in the planning, design, and construction of transportation projects, regardless of whether they work in the public or private sector (Ministry of Communication and Works, 2012). The Sustainable Urban Mobility Plan (SUMP) for Limassol followed in 2019 and the most recent Larnaca's SUMP in 2021 (Ministry of Communication and Works, 2023).

The most innovative and unique solution in terms of Sustainable mobility in Cyprus is the linear Park of Pedieos River. The park was constructed in different stages between 1999 and 2014. Its length is 14 km long, along the river. The park connects 3 municipalities, Lakatamia, Strovolos, and Nicosia with the historical centre of the city.

The park is narrow and shaded by large eucalyptus, pines, and palm trees along its first stretches in Nicosia (1.1 km) where it passes through a small, forested area (1.4 ha). The path gains gradually in

width in Strovolos, where it runs along the back of the gardens of the Presidential Palace. After about 3 km from its start in the city centre, the path splits into a separate lane for walking and cycling. The river becomes wider, and the path is more open and less shaded by tree canopy. Suspended, steel-framed wooden pathways have been constructed at the narrowest parts of the river and inside the bridges that cross busy roads. Plans have been prepared to extend the park by 14.2 km through Nicosia's suburban and rural surroundings (Interreg Europe - Sharing Solutions for Better Policy, 2023).

Despite the above-mentioned programmes and initiatives, their implementation doesn't go without its challenges. Firstly, the "Car-Centric Culture" where private car ownership is widely preferred and prioritized over other modes of transportation. This cultural mindset presents a barrier to the adoption of sustainable mobility options. Even this car-centric culture is overpassed, there is the barrier of lack of infrastructure and limited public transportation options. The inadequate infrastructure for sustainable modes of transport, such as cycling lanes, pedestrian-friendly paths, and efficient public transportation networks, along with the limited availability and reliability of public transportation systems poses a challenge to promoting sustainable mobility in Cyprus. In the past, land use planning and development decisions have not sufficiently integrated sustainable transport principles. This lack of integration hinders the creation of compact, mixed-use neighbourhoods that are conducive to sustainable mobility. These challenges are even further exacerbated in suburban and rural areas (Cyprus Energy Agency, 2017).

Moreover, Cyprus is facing urban sprawl, characterized by the expansion of cities and towns into suburban areas, that often results in longer commuting distances. The insufficient public transport options make it less convenient for people to choose sustainable modes of travel and thus, increases dependency on private cars, leading to higher carbon emissions and congestion on the roads.

The absence of financial incentives, such as subsidies or tax benefits, to encourage the use of sustainable transportation modes discourages individuals from choosing alternative options over private cars (Cyprus Energy Agency, 2017).

Awareness about the benefits of sustainable mobility options and education regarding their use and impact is relatively limited in Cyprus. Increasing awareness and educating the public can help overcome barriers to adoption (Cyprus Energy Agency, 2017).

Addressing these barriers requires a comprehensive approach that includes improving infrastructure, expanding public transportation, promoting sustainable urban planning, and raising awareness about the benefits of sustainable mobility (Cyprus Energy Agency, 2017).

In Greece

Unfortunately, in Greece, sustainable mobility has not been treated as a high-priority sector. Thus, there aren't many sustainability mobility actions that have been implemented in the country, and in cases where they have been some green mobility policies, they haven't been proven to be effective or widely accepted by the public. One striking example is the Great Walk of Athens.

The Great Walk of Athens (GWA) was developed as a defensive policy after the Covid-19 pandemic. It is an urban initiative of the Athens Municipal Council that aims to increase public space and allow citizens to practice social distancing, while at the same time promoting the use of bicycles or other non-typical transportation means and significantly reducing the circulation of cars in the city center. This sustainability mobility initiative has already been implemented on various crowded roads in the historic city center such as Syntagma, and Omonia, while there are plans to expand it to even more streets such as the street of Ermou that is planned to be converted into a vehicle-free street, except for some cars (Kalias, 2020).

But the GWA did not have the desired outcomes, despite the optimism of the initiative. This is due to the citizens' response to the implementation of the project. More specifically, citizens were dissatisfied because this mobility measure did not seem to equalize the consequences of the pandemic, something that it was mainly developed for. At the same time, the remodelling of the streets and the creation of this urban space for pedestrians and bicycles created even more traffic jams as it reduced the space for cars, which continued to circulate in those areas (Kyriakidis et al., 2023). Indeed, these undesired effects can be attributed to car-centric culture of Greeks, similarly as in Cyprus.

Indeed, the greatest barrier for the implementation of sustainable mobility initiatives in Greece is the prevailing ideology concerning transportation. More specifically, Greek cities are mostly car-centric, a phenomenon that is even more encouraged by the tendency for extended car ownership (Kyriakidis et al., 2023). Citizens in Greece prefer using their cars over public methods of transportation, something which ultimately means that they are not familiar with or fond of the way public transportation works. This logic of Greek citizens explains more or less the reason why the GWA has not flourished yet. And the reason is that there needs to be a change in ideology and in how citizens view transportation and sustainable mobility so that they do not view the areas of the GWA as "canals of movement" but rather as public spaces where social activities take place and that promote walking, cycling or even using an electric scooter (Kyriakidis et al., 2023).

Another policy that Greece has implemented to tackle traffic jams and increased circulation in the central streets is the "Alternate Day Circulation". This is a measure that aims to limit entrance in the

center of Athens by allowing the circulation of specific vehicles according to a regulation of odd/ even numbers which is called "Green Daktilios". To be exact, according to "Green Daktilios" vehicles that have an odd number as the last number on their driving plates can only enter the city center at odd days of the month during a defined period of time. The same goes for cars that have an even last number on their driving plate. In this context, hybrid or electric vehicles, low-emission engines, CNG and LPG cars are allowed to enter the city center despite the regulations, in an effort of the government to promote the use of more energy-friendly vehicles (Greek Travel Pages, 2021).

Lastly, the Ministry of Environment and Energy seeks to create Plans for Sustainable Urban Mobility, following the European paradigm, in order to create a more structured and practical framework for the implementation of various sustainable mobility policies (Greek Ministry of Environment and Energy, n.d.).

Besides the car-centric culture, another great barrier in moving toward sustainable urban mobility is the low quality of means of public transportation and the lack of a network that promotes interconnectivity between them. For example, a great public transportation network that promotes interconnectivity could be enhanced by the creation of a safe and effective bicycle path. This way, if bicycle paths were connected to the metro or the suburban railway, that would provide motive to citizens not only to get to their destination using public transport but also it would promote a new way of mobility with a bicycle, which is costless and environmentally friendly.

Another issue in Greece is overpopulation and the urban sprawl that is identified in urban centers. That leads to an extended number of citizens using the limited public transportation vehicles such as buses or metro lines creating big crowds and an unpleasant experience for users. This phenomenon also discourages car owners from using public transport more frequently. The solution to this problem could be to extend even more public transportation for example by making more busses available for use or creating more routes and more lines for the metro. Lastly, another important barrier that cannot go unnoticed is the lack of technological and economic resources that makes the extension of public transport or the implementation of new policies an even harder task.

In Ireland

Ireland is implementing a range of sustainable mobility solutions to reduce greenhouse gas emissions and improve air quality. Some of the main forms of sustainable mobility solutions being implemented in the country revolve around improving the public transportation option and promoting net-zero carbon emissions mobility solutions.

Ireland is investing in public transport, including buses, trains, and trams, to provide clean and efficient transport options. Dublin's light rail system, the Luas, has been extended in recent years, and a new

metro system is also being planned for the city. This is part of the sustainable transport planning that Ireland is undertaking. This involves designing and planning transport systems that prioritize walking, cycling, and public transport over private car use. The government has introduced policies to encourage denser, more compact development, which can reduce the need for car use.

In terms of cycling infrastructure, the investment includes dedicated cycle lanes, bike-sharing schemes, and bike parking facilities, to encourage more people to cycle. Dublin's bike-sharing scheme, Dublinbikes, has been successful in promoting cycling in the city.

Besides public transportation initiatives, on the private transportation sector Ireland is promoting the uptake of electric vehicles, with a range of incentives and grants available to encourage the purchase of electric vehicles and the installation of charging points. The government has also committed to phasing out the sale of new petrol and diesel cars by 2030.

One innovative and unique solution being implemented in Ireland is the e-Bikes for Business Grant Scheme. This scheme, which was launched in 2021, provides grants of up to €1,000 to businesses that purchase e-bikes for their employees. The aim of the scheme is to encourage more people to cycle to work, particularly for shorter journeys, reducing the need for car use and improving air quality. The scheme is also intended to help businesses reduce their carbon footprint and improve their sustainability credentials. The scheme is open to businesses of all sizes, and has been well received so far, with a high level of interest from businesses across the country.

There are several barriers to implementing sustainable mobility in Ireland, which can make it difficult to reduce greenhouse gas emissions and promote sustainable transportation.

One of the main barriers to implementing sustainable mobility in Ireland is the availability of funding. Sustainable transport infrastructure, such as cycling infrastructure and public transport systems, can be expensive to develop and maintain. In some cases, funding may not be available, or it may be difficult to secure funding for sustainable mobility projects.

Another barrier to implementing sustainable mobility in Ireland is the political will to prioritize sustainable transport solutions. Some politicians may be more focused on short-term goals or may be influenced by lobbying from the automotive or oil industries, which can make it difficult to implement long-term sustainable mobility solutions.

A major barrier to implementing sustainable mobility in Ireland is the challenge of changing people's behaviour. Encouraging people to use sustainable modes of transport, such as cycling or public transport, can be difficult if they are used to driving. There may be resistance to change, and it can take time to build new habits and change attitudes towards sustainable mobility. In some parts of Ireland, there is still a strong car culture, with many people viewing car ownership as a necessity rather

than a choice. This can make it difficult to promote more sustainable modes of transport, such as cycling or public transport.

Another barrier to sustainable mobility is the availability and quality of infrastructure. In some areas, there may be a lack of cycling infrastructure or inadequate public transport services, which can make it difficult for people to use these modes of transport. Improving infrastructure can require significant investment and may take time to implement.

In Netherlands

Even though the Netherlands faces a range of challenges in addressing climate change, the country is committed in taking action and has set ambitious targets to reduce emissions and transition to a low-carbon economy. Addressing these challenges, a wide range of sustainable mobility solutions has been involved, as well as a commitment to finding innovative solutions (Government of the Netherlands, 2020).

Public transportation in the Netherlands consists of urban transport, regional transport, and rail transport such as bus, tram, underground (Metro), light rail, and train. By switching to alternative fuels, the use of sustainable infrastructure and sustainable materials is planned for the achievement of more sustainable mobility (Government of the Netherlands, 2020).

By 2030, all new passenger cars are mandated to be emission-free, with incentives for electric vehicles being provided through several taxation measures, including support for the used car market. Additionally, 1.8 million charging points are planned to be installed by 2030 to facilitate the transition. Additionally, beside electric vehicles, action is also being taken in terms of sustainable fuels. The government has drawn up a vision for a sustainable fuel mix for the future, explaining which fuels can best be used to power aircraft, ships, trains, and road vehicles. Some examples of those fuels are biofuels, green gas, non-fossil aviation fuel, and hydrogen (Government of the Netherlands, 2020).

To date, the Netherlands is a country with important initiatives on sustainable mobility, including cycling infrastructure, electric vehicles, and public transportation. However, there are still some barriers to implementing sustainable mobility in the country.

One of the main barriers to sustainable mobility in the Netherlands is the necessity to extend infrastructure. While the country is known for its cycling infrastructure, it is necessary to extend this infrastructure in areas outside of major cities to support cycling or walking as a mode of transportation. In addition, infrastructure for electric vehicles and public transportation can also be improved, particularly in rural areas.

While the long-term use of sustainable modes of transportation can be cost-effective, it often requires a significant upfront investment. A possible barrier for individuals or communities can be the disability to proceed with the necessary financial investments. Another money-consuming change that is necessary is the change of land use.

Even though the Netherlands has made significant progress in the implementation of sustainable mobility, there is still resistance from some interest groups that prioritize other concerns over sustainability (Alonso-González et al., 2020).

In Portugal

Currently, Portugal is undergoing a transportation reform (*Reforma do Ecossistema dos Transportes*).

Since 2019, a program has been implemented to reduce public transportation costs for users and since 2020 funding have been applied to reinforce the current services and the implementation of new public transport services, reach more territory, and increase overall accessibility between the population and main centers. Moreover, the reform plan includes the renewal of public transport fleets (acquisition of clean vehicles and charging stations to replace fossil fuel vehicles) and the extension of the network for the two main cities, Lisbon and Porto, as well as the modernization of their infrastructures (Recuperar Portugal, 2023).

Sustainable public transportation usage has also been promoted by the implementation of tax policies like tax deductions on monthly transport passes (Recuperar Portugal, 2023).

On the private transportation sector, cycleway networks have been expanded as well as the electrical charging points. Additionally, incentives are being implemented for the acquisition of 100% electric vehicles to individuals and legal entities, including motorcycles and bicycles (Recuperar Portugal, 2023; CE, 2007).

Moreover, to achieve a mobility transition towards sustainability, public-private partnerships have been encouraged to develop innovative sustainable mobility solutions, including electric vehicle-sharing services and integrated mobility platforms (Recuperar Portugal, 2023; APA, 2010; CE, 2007).

Another crucial aspect is the promotion of soft mobility – transportation methods that use non-motorized means - such as walking and cycling. Cycling infrastructure and pedestrian zones have been created in several cities to encourage the use of these more sustainable modes of transport, improving quality of life and reducing air pollution (APA, 2010).

In summary, sustainable mobility in Portugal involves the implementation of policies and practices that promote the use of efficient public transport, active mobility, and the decarbonization of the transport sector. These measures aim to reduce greenhouse gas emissions, improve air quality,

increase accessibility, and improve people's quality of life. Through these actions, Portugal is moving towards a more sustainable future regarding mobility.

Despite these investments and programmes, the public transportation network is still insufficient for the Portuguese population. In urban matrixes, public vehicles frequency and accessibility is still inadequate in its response to the large affluence (Naranjo et. al., 2022; Ramos et. al., 2019). This is also supported by a recent study, conducted on college students from several Portuguese institutions, where the majority revealed their preference for private cars (47% as drivers plus 5% as passengers) as a way to commute between home and college facilities. The main factors that the students considered whilst choosing their way of mobility were convenience (21%), time (17%), availability and cost (13%) (Anabela et. al., 2022).

 Urban areas show pockets of mobility isolation and this scenario is even worse in rural areas. Some of them lack public transportation infrastructures altogether whilst others present inadequate conditions to ensure passengers' safety and comfort and are in desperate need of improvement (IMTT, 2008; Fernandes et. al., 2009). Lack of accessibility leads to social exclusion, especially of certain population groups such as the elderly (Ribeiro et. al., 2021).

Moreover, Portugal belongs to the group of countries without a culture of bicycles for commuting in urban areas. The country also presents a challenging orography that puts off many citizens from using soft transportation, this is a barrier hard to surpass. To promote their use some measures were already adopted but they monthly focus on the design of dedicated structures, like bike paths and eco-ways (IMTT, 2008) however, more connectivity and security in these paths is needed to bring more users. Additionally, studies show that for a successful implementation of bicycle commuting, they should be integrated with other modes of transport as a way to overcome topography and other challenges. The National Strategy for Active Mobility aims to increase bicycle modal share from the current level of below 1% to 10% by 2030. (Fonseca et. al., 2023; Lopes et. al., 2021).

Lastly, public transportation usage is associated with low-income population strata whilst car usage and ownership is a symbol of status. Like Cyprus and Greece, Portugal also has a car-centric culture (APA, 2010).

Practical Guidelines

STEAM EDUCATION – Implementation Programmes & Challenges

General Findings

STEAM Education is a new approach to learning, the letters state for: **S**cience, **T**echnology, **E**ngineering, the **A**rts, and **M**athematics. It is a multidisciplinary approach that aims to guide students' inquiry, dioalogue, and critical thinking. The integration of STEAM education in European schools is a priority and key pillar to innovate the educational system in a way that will better equip young learners for the challenges of tomorrow. Its interdisciplinary nature makes STEAM education a particularly useful approach to teach a complex topic such as climate change.

Due to its novelty, there is still a lack of resources made available for teachers. Additionally, the unfamiliarity with the approach can make professionals sceptical about using it in the classrooms. STEAM education is also very reliant on technological tools and skills, this is a major barrier to its wide implementation in schools since teachers often lack the appropriate training and adequate resources in the classrooms.

In Cyprus

State of STEAM Education

Over the past decade, and more concretely since 2021, STEAM Education in Cyprus has been progressively drawing both attention and support from the state as well as from independent entities. Ever since several initiatives related to STEAM learning have been pursued to enrich opportunities for student engagement nationwide. Stakeholders acknowledge that STEAM Education can potentially act as an enabling agent in fostering a sustainable economy and a robust workforce (Government Policy Document). Hence, steps have been taken to encourage STEM integration in schools and tertiary institutions through the implementation of curricular enhancements, the support of teachers' training, and the provision of resources to teaching professionals.

Initiatives led by the Ministry of Education and/or the Cyprus Pedagogical Institute aiming to promote and enhance STEAM Education included yet were not limited to:

- **Curricular Integrations:** The Ministry of Education, Culture, Sports, and Youth in Cyprus has been working to integrate STEAM concepts into the national curriculum across different grade levels. This integration aims to introduce students to STEAM subjects early on and help them develop essential skills and knowledge.

- **Teacher Training**: Professional development programs for teachers have been conducted to equip them with the necessary skills and tools to effectively teach STEAM subjects. This approach ensures that educators are well-prepared to deliver high-quality STEAM education to their students.

- **STEAM Competitions and Challenges:** Cyprus hosts various annual STEAM-related competitions and challenges for students, encouraging them to showcase their skills and innovative ideas. Such events provide motivation and recognition for students to excel in STEAM fields.

- **Public Awareness Campaigns:** The government and various independent organizations occasionally launch public awareness campaigns to highlight the importance of STEAM education and its impact on society and the economy. These campaigns aim to encourage parents, students, and educators to engage more actively in STEAM activities.

Similarly, the industry sector in Cyprus has recognized the significance of STEAM skills for the future workforce. Companies of various backgrounds have shown tangible support by collaborating with educational institutions, sponsoring events, providing mentorships, and offering internships to students interested in STEAM fields. Such industry partnerships have proven crucial in bridging the gap between theoretical knowledge and practical application, giving students real-world experience. Furthermore, European funding for STEAM-related educational programs and initiatives, run by various NGOs and Project Centres, have been made available to support schools and educators in their pursued implementations.

Samples of such state and independent initiatives are provided below:

1. **Implementation of a STEM pilot state program in Cypriot Primary Education (2021 - 2022)**

This state pilot initiative engaged eight primary schools from November 2021 to May 2022, promoting an integrated interdisciplinary learning approach. In the course of its implementation, children participated in various activities addressing real-life, world-related issues and challenges. In the course of their interaction, they had the opportunity to utilise and challenge their pre-existing knowledge and understandings, while being introduced to new STEM-related concepts, processes and practices. The eight schools selected to participate in this pilot implementation were part of the Optional All-Day School (OAS) system, incorporating the programme into their existing afternoon timetable. The program was offered twice a week for an 80-minute duration per session, to Gade 6 primary students allowing them to design, test, further develop and propose innovative solutions to practical problems. Teachers with postgraduate qualifications and/or experience in teaching STEM subjects delivered the STEM program having priorly received relevant training offered by the Directorate of Primary

Co-funded by
the European Union

Education, in collaboration with the Pedagogical Institute. The operation of the STEM program is expected to be adjusted and onwards implemented in Secondary Schools in the near future. To learn more: https://eurydice.eacea.ec.europa.eu/news/cyprus-implementation-stem-pilot-program-primary-education

2. **The STEAMers (recurring)**

STEAMers programme is organised by the Cyprus Youth Board offering a series of all-year-round workshops on Robotics, Coding, Film-making, Photography, Graphic Design, Creative Writing, Music, Drama and Art. The programme operates along the international S.T.E.A.M Centres standards aiming to cultivate young people's creative development, to further enrich their entertainment and learning experiences, develop their communication skills, as well as increase their capacity for innovation. The workshops are being delivered by field expert professional trainers and operate in three different districts, Nicosia, Limassol and Paphos consisting of 30 annual sessions per discipline. Children and young people, aged 6-35, are provided with the opportunity to gather together, experiment, apply their creativity, acquire new skills and further cultivate their interests. To learn more: https://onek.org.cy/en/programmata-ypiresies/dimiourgiki-apascholisi/the-steamers/

3. **"sCYenceFair2023": Science & Innovation for Tomorrow's Young Researchers (2023)**

"sCYenceFair2023" is the largest annual Science Festival in Cyprus, co-organized by The Cyprus Institute (CYI) and the Cyprus Pedagogical Institute's (CPI) Education Unit for the Environment and Sustainable Development (UEESD). This year's event (2023) was placed under the auspices of the Ministry of Education, Culture, Youth and Sports (MOECYS) and hosted at the Cyprus Institute's premises. Through an array of scientific activities, experiments and product exhibitions it aspired to stimulate young students' scientific interest and encourage their participation in Science affairs. The event served as an opportunity for students to raise their awareness surroundings the latest and most captivating science advancements in various fields of study, further their knowledge, and broaden their scientific horizons. Moreover, this year's festival was supported by the representation of the European Commission in Cyprus, alongside various EU Member States Embassies cohosting activities and showcasing national science exhibits. 67 student teams across public and private schools in Cyprus grasped the opportunity to present their innovative scientific projects. The most prominent of those were awarded in their respective categories based on the underlying scientific innovation, their prospective impact, and their overall presentation. To learn more: https://scyence.cyi.ac.cy/en/

4. **Sci-Tech Challenge Programme (2023)**

Sci–Tech Junior Achievement Cyprus and ExxonMobil Cyprus co-organised this year's (2023) Sci-Tech Challenge Programme in Nicosia. This international programme runs for the third consecutive year in

Cyprus, accounting for the participation of more than 60 000 students from all over Europe, marking its 12th anniversary since its inception. It pursues to inspire students to pursue Science, Technology, Engineering, and Mathematics (STEM) courses at higher education levels, to acquaint them with a wide variety of STEM careers and to leverage their talents. The year's programme (2023) was implemented in 14 schools bringing 411 students face-to-face with real-life environmental challenges. Volunteer mentors from ExxonMobil performed numerous classroom visits introducing students to the main energy challenges and presenting ExxonMobil field experts working on those. A total of 70 youngsters constituting 14 student groups participated in the Sci-Tech Challenge Competition providing them with the opportunity to share their ideas and proposed solutions to global problems. To learn more: https://www.exxonmobil.be/en-be/community-engagement/sci-tech-challenge

5. **EL-STEM – Enlivened Laboratories within STEM Education - Erasmus+ Funded Project (2017 - 2020)**

This was an Erasmus+ / KA2, Strategic Partnerships for School Education Project aiming to promote STEM studies & careers among EU students while improving their performance in courses related to STEM education. Specifically, the project aimed at fostering an innovation "ecosystem" among European secondary schools (ages 12-18) able to effectively and efficiently facilitate a user-centric design, utilising Augmented Reality AR/MR resources for personalised STEM learning and teaching. The project developed, pilot-tested, and implemented an innovative professional development program familiarizing teachers with the potential of AR technology for enhancing instructional practices and students' motivation and learning processes in secondary STEM education. Teachers were familiarised with ways in which they could employ AR (but also VR/MR) to promote students' engagement in STEM education and strengthen their 21st-century skills. To learn more: http://elstem.eu/

Challenges of STEAM Education Implementation

Due to its novelty, there's an absence of extensive literature documenting the local ground realities surrounding the implementation obstacles of STEAM Education - this report has instead sought refuge to the documented hindering factors of Education for Sustainable Development (ESD) implantation. The challenges presented are speculative inferences of what may similarly apply for STEAM education implementation.

One of the main obstacles to implementing STEAM education in Cyprus is closely related to the existing national curricula and respective educational policies. Introducing STEAM Education requires significant reforms to the traditional education system and a major revision of mainstream educational practices.

One of the necessary revisions concerns teachers training and support in implementing STEAM resources in the classroom. Implementing STEAM effectively requires teachers who are content-proficient and well-versed in interdisciplinary approaches. Providing adequate training and professional development opportunities to educators to enhance their skills in STEAM methodologies is an ongoing challenge for state agencies mandated with the relevant responsibility in doing so. Furthermore, the existing assessment methods are not well-suited to evaluating the interdisciplinary nature of STEAM education. Designing an appropriate evaluation framework effective at measuring student progress and success in STEAM subjects is both a requirement and a challenge.

Additionally, STEAM education presupposes the integration of technology and digital tools, which may require investments in infrastructure, equipment, and software. Resource constraints, both financial and technological, could hinder the smooth incorporation of technology into classrooms.

Indeed, technological infrastructure or access to digital tools required for implementing STEAM is either inadequate or inexistent in Cypriot secondary schools. The current budgetary allocation for Education hardly addresses the upkeep and maintenance costs of the existing infrastructure, let alone its extensive cross-sectorial upgrade.

As with any significant educational reform, moderate resistance to change from various groups (teaching unions, organized groups of special interests, traditionalist practitioners, political parties etc.) reluctant to deviate from the traditional education model can pose a significant setback in the process. At a more local level, there might be a lack of awareness and understanding among educators, parents, and policymakers about the benefits of STEAM education. Building consensus and garnering support for its implementation could prove difficult.

Addressing these obstacles and hindrances requires the collaborative efforts of policymakers, educators, and local stakeholders. At the same time, providing ongoing support, targeted training opportunities and relevant resources to educators, while maximising investments in infrastructure and technology, are all critical to fostering a deeper understanding of STEAM education's benefits, securing its effective implementation.

In Greece

State of STEAM Education

STEAM education in Greece is a very recent movement that has been developed over the last seven years. So, STEAM education is not officially a part of the educational curriculum, in the sense that its implementation is not mandatory. The majority of Greek schools do not utilize the STEAM method but instead mostly choose to follow the traditional educational system which includes teaching science,

technology, arts and mathematics separately. Nonetheless, there are certain innovative initiatives that aim to incorporate STEAM into the Greek educational curriculum.

The Institute of Educational Policy (IEP), which supports the Ministry of Education and Religion, has created a framework called **"Skills Workshops"**. These Workshops are an educational initiative that has the purpose of initiating the addition of new thematic sections in the official curriculum in Greece, focusing mostly on primary and secondary education. Through the implementation of these workshops, IEP and the Ministry aim to promote the cultivation of new competencies, life skills, technological and digital capabilities, critical thinking, etc in students. The initiative has been put into action by law and has also been published in the Press of the Government of the Hellenic Republic in 2021 (Num. 94236/ΓΔ4, 2021). In this context, IEP has put out an invitation to every educational Institution interested in uploading educational content relating to every respective thematic section (Institute of Educational Policy, n.d.). The section "Creating and Innovating – Creative Thought and Initiative" includes STEM education and Robotics. Also, the Greek School of Philosophy and the Pedagogical Department of Secondary Education have already uploaded a curriculum for STEAM, which offers the necessary content and directions for its use in schools (IEP, n.d.).

Many of the projects about STEAM education are supported and implemented by the Ministry of Education and Religion and the Institute of Education Policy (IEP). Some of them are:

1. **"Robotics & STEAM FLL – GAME CHANGERS":** It is a program of educational robotics, under the umbrella of "Skills Workshops", that is implemented in some pilot schools that have been chosen throughout the country. It aims at introducing students to digital society and strengthening their scientific and real-life abilities (Ministry of Education and Religion, 2021).

2. **"Experiential Program STEAM":** The Directorate for Educational Technology and Innovation in cooperation with the Ministry of Education and Religion is going to implement an immersive seminar titled "Experiential Program STEAM", addressed to students of Primary and Secondary Schools. The seminar will include topics such as chemistry, biology, geography etc through the philosophy and methodology of STEAM, using tools such as experiments and creative crafts (Edu-Gate, 2022).

Challenges of STEAM Education Implementation

To begin with, a timeless issue that obstructs the implementation of STEAM education in Greece is the lack of technological resources and equipped personnel. In specific, most schools do not have the necessary technological infrastructure, except for a few computers and projectors, to implement the innovative initiatives of STEAM education. Although, there has been an effort from the Ministry of Education and Religion to equip schools via competitions. For example, the Ministry declared an Open International Electronic Competition for the supply of robotics and STEM equipment for education.

Through this competition, the Ministry seeks to reach out to businesses that are able to equip primary and secondary schools with robotics sets and software (Ministry of Education and Religion, n.d.). Additionally, another problem that arises is that not enough teachers are familiar with the concept of STEM and STEAM education. The number of teachers and trainers that have participated in STEAM education seminars or that have been trained accordingly is insignificant. What needs to be done is for the official educational institutions to create seminars and trainings presenting the methodology of STEAM, educating teachers on how they can implement it in the classroom and providing them with the appropriate educational tools. These trainings in Greece are mostly distributed by private institutions.

At the same time, to implement STEAM methodology teachers need to be open to the idea of cooperating with their colleagues to conduct the lesson. This is because STEAM introduces the interconnectivity of two or more lessons and therefore is based on the method of teaching one subject via another one, something that requires the participation of more than one teacher. For example, physics can be connected with chemistry or mathematics and the teaching process can be conducted through the use of technology. Thus, in this case, the physics and chemistry or maths teachers need to not only cooperate but also have basic technological skills at the same time. This way of teaching is not very widespread in Greek schools and there is a need for teachers/ trainers to reconsider the traditional educational methods they have previously used.

In Ireland

State of STEAM Education

STEAM education (Science, Technology, Engineering, Arts, and Mathematics) is a priority in Ireland, with significant government support and industry engagement. STEAM education is seen as crucial to developing the skills needed for the future economy and to preparing students for careers in a wide range of fields.

The government has made significant investments in STEAM education in recent years, with a range of initiatives and programs aimed at improving access to and the quality of STEAM education in the country. For example, the government's STEM Education Policy Statement 2017-2026 outlines a vision for STEAM education in Ireland, with a focus on developing students' creativity, critical thinking, and problem-solving skills. The policy statement also sets out a range of actions to support STEAM education, including improving teacher training, promoting industry engagement, and increasing access to STEAM education for underrepresented groups.

Industry engagement is also a key feature of STEAM education in Ireland. Many companies are actively involved in supporting STEAM education initiatives, either through funding, providing resources, or collaborating with schools and universities. For example, Intel Ireland runs a range of education programs, including the Mini Scientist program, which encourages primary school students to engage

Co-funded by
the European Union

in science and engineering activities, and the Intel Women in Technology Scholarship program, which aims to encourage more women to pursue careers in technology.

In terms of specific initiatives, there are a range of educational and promotional initiatives that have been implemented to support STEAM education in Ireland. For example, the Discover Science and Maths program is a national program that provides resources and support to schools to help them develop science and maths programs. The program also offers awards to schools that demonstrate excellence in science and maths education. The CoderDojo movement, which was founded in Ireland, is also a popular STEAM education initiative, providing free coding clubs for young people.

Overall, STEAM education is a priority in Ireland, with significant government support and industry engagement. The range of initiatives and programs aimed at improving access to and the quality of STEAM education in the country reflects the importance placed on developing the skills needed for the future economy and society.

Challenges of STEAM Education Implementation

While there is significant support for STEAM education in Ireland, there are also several obstacles that can prevent its implementation. One of the main challenges is ensuring that all students have access to high-quality STEAM education, regardless of their socioeconomic background. There is a concern that students from disadvantaged communities may be less likely to have access to the resources and support they need to fully engage with STEAM education. This can lead to disparities in STEAM education outcomes, with some students missing out on the benefits of STEAM education.

Another challenge is ensuring that teachers are adequately trained and supported to deliver high-quality STEAM education. Teachers may not have the necessary skills or confidence to teach STEAM subjects, or they may lack access to the resources and training they need to develop their skills. There is a need for ongoing professional development and support for teachers to help them effectively integrate STEAM education into their teaching.

Integrating technology and digital tools into STEAM education can also present challenges. While technology can be a valuable tool for STEAM education, there is a risk that it can be seen as a solution in and of itself, without considering the pedagogical approaches needed to effectively integrate technology into teaching and learning. There is a need for careful planning and design of STEAM curricula that take into account the appropriate use of technology and digital tools, as well as ensuring that teachers have the necessary skills to effectively use them.

Finally, there is a need to ensure that STEAM education is not seen as an isolated subject area, but rather is integrated into the wider curriculum. This can be challenging, as STEAM subjects may be seen as separate from other subjects, or may not be prioritized in the curriculum. To address this, there is a need for a more holistic approach to education that integrates STEAM subjects with other subjects and encourages cross-disciplinary learning.

Overall, while there is significant support for STEAM education in Ireland, there are also several obstacles to its implementation, including access to resources and support, teacher training and support, integrating technology and digital tools, and ensuring that STEAM education is integrated into the wider curriculum. Addressing these challenges will require ongoing commitment and investment from the government, industry, and education sector.

In Netherlands

State of STEAM Education

STE(A)M is an educational approach that integrates Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student inquiry, dialogue, critical thinking and the acquisition of these competencies. It incorporates gender-inclusive teaching methods and open resources focused on STE(A)M learning in primary education; to foster creativity, critical thinking and problem-solving competencies among young pupils in STEM. The focus on STEAM education in the Netherlands is rising with a particular emphasis on promoting innovation and entrepreneurship. The government and industry have both been active in supporting STEAM education through a range of initiatives.

Government support: The Dutch government has made STEAM education a priority, to prepare students for the jobs of the future, and foster creativity, critical thinking and problem-solving competencies among young pupils in STEM. The Ministry for Primary and Secondary Education and Media has set up an independent scientific committee (Curriculum Committee). The government provides funding for STEAM programs and has also established SLO, a national platform that involves STEAM education, to coordinate efforts and share best practices.

Industry partnerships: Many companies in the Netherlands are actively involved in promoting STEAM education, through partnerships with schools and universities, internships and apprenticeships, and other initiatives (Government of the Netherlands, Ministry of Education, Culture and Science).

Some important educational or promotional initiatives that contribute to the improvement of STEAM education are projects that promote the cooperation between universities, teachers, school leaders, educational organizations and other stakeholders.

A specific example of those projects is the STEAM it UP project (https://steamitup.eu/en/) which aims to the development of an interdisciplinary STEAM program to empower students, school leaders, school staff and school communities to apply STEAM activities, robotics and digital tools to develop 21st-century skills for students (creativity, problem-solving, self-esteem and collaboration). Part of this project is the STEAM program ROOTS which is an after-school community program that offers a space where families, educators, visiting scientists and artists come to work together on science investigations.

Another initiative is the project Generation AI (https://generation-ai.eu/). This project aims to support educators and young learners understand the basic principles of AI and help them become more critical consumers of technology applications across their life span based on STEM educational approaches.

Challenges of STEAM Education Implementation

STEAM education is an approach that is based on the integration of multiple disciplines of Science, Technology, Engineering and Mathematics with the Arts and is considered an innovative approach that contributes to the development of 21st-century skills to the students. While the Netherlands has made significant progress in promoting STEAM education, there are still challenges that need to be confronted.

One of the main obstacles to implementing STEAM education in the Netherlands is a need for further teacher training and development concerning the integration of multiple disciplines in an interdisciplinary approach. Many teachers may not have the necessary skills or knowledge to teach STEAM subjects effectively, particularly when it comes to integrating technology and digital tools into the curriculum while other teachers implement STEAM modules as if the various disciplines are separated rather than integrated. Another obstacle is the low accessibility to innovative resources, particularly in schools with limited funding, rural areas, or disadvantaged regions with fewer opportunities. In general, there is low accessibility to students with fewer opportunities that face any kind of difficulty: geographical, economic and social obstacles, disability etc. This can include access to technology and digital tools, as well as access to high-quality materials for hands-on learning activities. Finally, a significant challenge to confront is teachers' perceptions and attitudes toward the STEAM approach. Many teachers feel unconfident to implement knowledge and skills from multiple disciplines especially if those disciplines are beyond their expertise.

Especially, when it comes to integrating technology and digital tools into STEAM education, there can be more challenges concerning the necessities of funding, the inclusiveness of vulnerable students that should be ensured, as well as technical issues such as accessibility, compatibility of the tools etc.

In Portugal

State of STEAM Education

Portugal along with the EU community has invested in STEAM methodologies and teachers training. Their implementation in Portuguese schools is of mandatory application in primary education within natural science classes. However, the STEAM materials are often not perceived as such due to being a novelty in the educational system that often doesn't use the acronym – STEAM or CTEAM in Portuguese (Bonito & Oliveira, 2022). Within the educational ministry supporting document for

environmental and sustainability teaching, the words "STEAM", "CTEAM" or "interdisciplinaridade" (interdisciplinarity) cannot be found (Referencial, 2018).

As part of the country's resilience plan, 8 million has been invested in the programme "Impulso Jovem – STEAM Ciência Viva" which aims to improve STEAM competencies by expanding the "Ciência Viva" clubs' network, the partnerships between stakeholders. This initiative was created in collaboration with Aveiro municipality, and the goal is to develop 650 projects that intend to improve scientific learning through experimentation and interdisciplinarity (Barba, 2023). Odivelas municipality also worked towards the integration of STEAM methodologies in school education by the creation of "Academia de Cidadania Digital" (Academy for Digital Citizenship). These initiatives aim to provide interactive learning environments and continuous teacher training on the STEAM approach, integrating media literacy and fostering social and emotional skills development in children.

Additionally, some environmental NGOs have being developing educational resources as a way to bridge the gaps in school curricula in terms of environmental literacy and, above all, promote dynamic learning. ASPEA, for instance, works in both formal and non-formal education formats, also develops teachers-training sessions and establishes partnerships with schools (ASPEA, 2022). Another ONG dedicated to nature conservation and sensibilization is the LPN. Besides holding environmental education formations and workshops they also developed publicly available resources that make use of several methodological formats: games, experimentation, artistic expression, text and graphic content, videos and more (LPN, 2022).

Challenges of STEAM Education Implementation

The theme of Digital Educational Resources (DER) and institutional electronic repositories is emerging as a trend in education in Portugal, particularly in primary and secondary education. The wide range of open content from various sources has led to the conception and development of repositories that systematize DER. This facilitates their availability and dissemination within the educational community, simplifying the teachers' task of accessing a broad set of relevant resources However, the establishment of repositories faces some challenges that hinder their implementation, which are not directly dependent on the controlling institutions. These challenges include the unavailability of broadband and the lack of resources to invest in hardware and software. Moreover, institution's homepages do not refer to their repositories, which may indicate their lesser centrality in institutional policy or a lack of emphasis on their role. This leads to two threats: the implementation of the repository becomes more constrained, and it may be undervalued by the target audience and also the absence of a defined public data preservation policy may lead to a threat of reduced author confidence in the security of their content, potentially inhibiting collaboration (Castro et. al., 2011).

The digital skills of teachers were put to the test worldwide during the Covid-19 pandemic. Primary and secondary education teachers in Portugal, need to enhance their digital competencies despite showing moderate digital proficiency (Trindade et. al., 2021).

The lack of widely available resources and digital literacy in the educational systems form a barrier to the integration of digital tools into STEAM education.

Strategies & Challenges in implementing climate change education –

Engaging Methodologies & Strategies for CCE STEAM education: In Cyprus

Current approaches to teach about climate change, sustainable mobility and STEAM education

Since its establishment in 2018, the Unit for Education for the Environment and Sustainable Development (UEESD), serving under the supervision of the Cyprus Pedagogical Institute (CIP) - has been institutionally mandated to advance, support and oversee the development and deployment of effective strategies aiming to support engagement and learning among students.

The strategy and corresponding actions developed and deployed over time have been closely related to the promotion of Education for Sustainable Development (ESD). In line with the goals set by the UN's ESD Roadmap 2030, UEESD has taken tangible measures in support of the following UN priorities related to climate change, sustainable mobility and STEAM education. These measures and actions covered the following Priority Areas:

- UN Priority Area 2: Transforming Learning Environments

- UN Priority Area 4: Empowering and Mobilising Youth

- UN Priority Area 5: Accelerating Local Actions

Following is a brief reference to the actions associated with each of the above priorities.

1. **UN Priority Area 2: Transforming Learning Environments**

The introduction of the ESD National Curriculum in Cyprus, marked a new educational era for ESD nationwide, "highlighting the transition from the marginalized and occasional study of environmental issues in schools to a holistic approach which sets these as an integral part of the educational vision and policy of each school in the country" (Zachariou, 2021).

In Cyprus, the whole-school approach (WSA) is being applied through the implementation of the Sustainable Environmental Educational Policy (SEEP) by every school. The School

Effectiveness Program (SEEP) is developed and implemented by the entire school, addressing the needs and particularities of the school unit and environment. It requires community cooperation, collaboration networks, and self-evaluation at pedagogical, organizational, and social levels.

The idea of transforming learning environments in the Cyprus Curriculum of EESD is being captured through the reorientation of schools towards the whole-institutional approach/whole-school approach (WIA/WSA), alongside the formation of a community of learning for ESD through changes on a: 1) pedagogical level, by strengthening pedagogical and teaching approaches; 2) organizational level, by using schools as a pedagogical and educational tool; and at a 3) social level, by the development of cooperation networks with organizations and institutions.

In Cyprus, the SEEP is an official whole-institution policy adopted officially by pre-primary and primary schools and the preparation of SEEP by each school is mandatory since 2012. Below, you can see the steps for developing a SEEP:
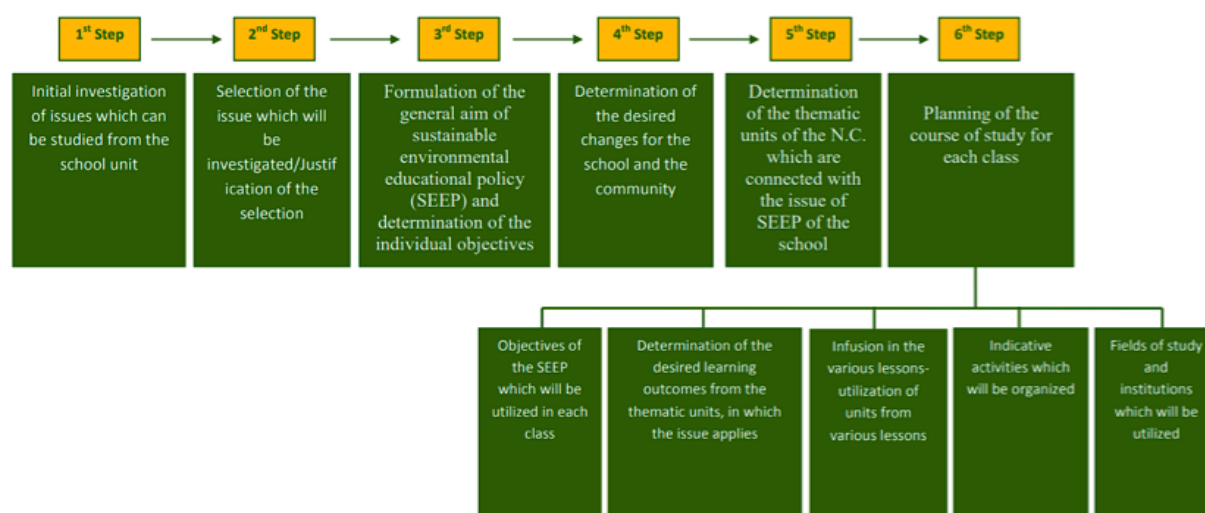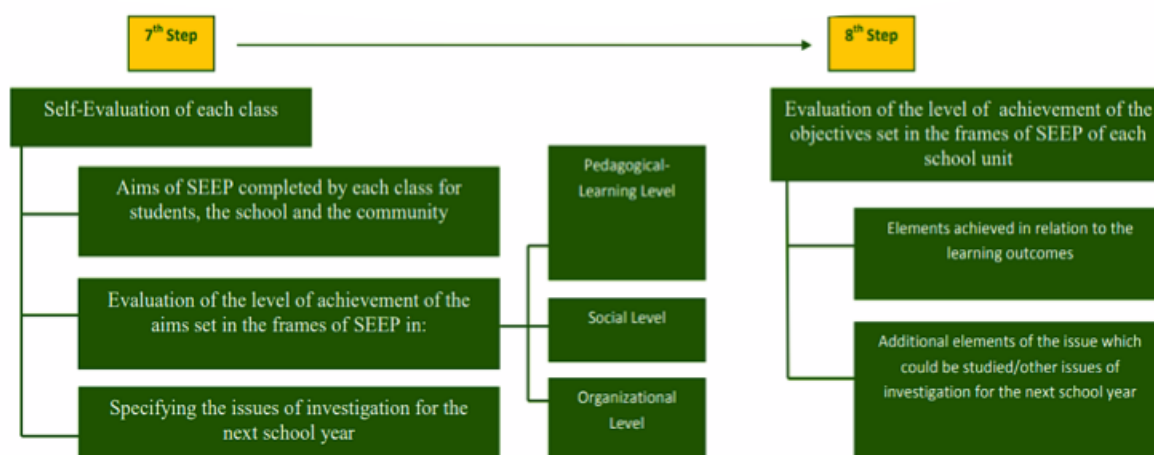
2. **UN Priority Area 4: Empowering and Mobilising Youth**

The aim of empowering and mobilizing youth is being achieved in various ways throughout the years. The national curriculum with its holistic and interdisciplinary approach as well as the variety of topics (12 thematic units) that are incorporated into the learning process, allows young people to develop their critical thinking and a broader understanding of the issues of EES "through the social, political and cultural aspects, along with the environmental" (Cyprus Ministry of Agriculture, Rural Development and Environment, 2022, p. 206). Since each school participates in the design, organization and implementation of their own SEEP, the programnne is tailored to meet the needs and interests of the students as well as the particular characteristics, challenges and needs of the community. Students of all ages are being mobilized and empowered to offer to their communities and sensitize their peers and local communities. Two of this targeted youth mobilization programs are described here described:

- Action Against Climate Change: The Climate calls "S.O.S" - The programme aimed to raise awareness about the systemic effects of Climate Change through visual arts, with students expressing anxiety and calling for immediate action.

- Travelling SDGs Suitcase - The programme aims to educate and mobilize Cypriot citizens to improve quality of life and create sustainable societies. A total of 17 books will be developed for each Sustainable Development Goal (SDG), focusing on local to global cooperation, intergenerational communication, action for change, and sustainable transformation.

3. **UN Priority Area 5: Accelerating Local Actions**

Community action is an integral element of Education for Sustainability, responsible for initiating the design and implementation of environmental education programs in schools

(Zachariou, Symeoy and Katsikis, 2005). Since 2003, Cyprus brought to bear various state-wide community action programs, such as the *"Design the Environmental Education Programs with the Involvement of Parents and the Local Community"* and the *"Environmental Education Projects in the Community"*. Their aim was not confined to training in-service teachers on how to organize, design and apply Environmental Education (EE) projects in each school's local community but also to promote the actual implementation of community action programs which will have an impact on the development of networks and collaboration between schools and various community groups (Zachariou & Symeou, 2008. Zachariou, Symeoy and Katsikis, 2005). These programmes provenly impacted students' learning and engagement throughout their implementation.

The establishment of the National Network of Environmental Education Centers (EEC) is an indicative example of the cooperation between the Ministries, the private sector such as NGOs and the local communities, to develop education programmes (informal and non-formal) specific for the community needs (MoEC, 2019, p. 61). There is also a priority task for schools to become sustainable in the long term by their SEEP (MoEC, 2019).

Limitations to the current methodologies and strategies used to teach about climate change, sustainable mobility and STEAM education

Limitations and gaps evident in Climate Change Education and Education for Environmental Sustainability (EES) within the Cypriot educational context, are not limited to methodological and strategic approaches but tend to extend to systemic barriers and hindrances instead. According to the "Study to investigate the national and institutional policies and approaches to education for environmental sustainability" the following perceived challenges and barriers affect the provision of EES.

Practitioners' resistance to adhering to the whole-institutional approach of the ESD curriculum has proven significantly challenging. Given that the new curriculum transitions from a fragmented approach to dealing with environmental and sustainable development issues to a holistic one, an advisory / mentoring pedagogical team was appointed to guide schools on how to implement the ESD curriculum. These ESD advisors are visiting schools providing support and guidance in applying the ESD curriculum according to the schools' needs and contextual particularities.

The overloaded nature of the Cypriot curriculums alongside the disproportionate emphasis on the so-called "primary subjects" such as Mathematics, Language, Sciences etc., serves as an inhibiting factor to the successful implementation of ESD. In response to this risk and challenge, 2 teaching periods have been allocated to the weekly school timetable aiming to integrate ESD

into Grades 1-4. Similarly, 1 teaching period has been allocated for Grades 5-6 aiming to introduce the subject of Life Education ("Αγωγή Ζωής"). Additionally, the inclusion of non-formal education as a mandate in schools, and the opportunities that have been provided to integrate the ESD curriculum within this channel, help to address this challenge.

The absence of a comprehensive mechanism for ESD assessment constitutes a challenge itself. This calls upon the need to shift away from traditional forms of evaluation which are purely assessing content knowledge. In response to this challenge, UEESD has been devising a framework of qualitative methods of assessment, whereby students are expected to submit an ESD portfolio as part of their end-of-year formative assessment.

A critical challenge encountered by the educational system in Cyprus during the COVID-19 pandemic was the rapid transition to distance learning. This has proven a Sisyphean task taking into consideration the incompatibility of distance learning and ESD implementation requiring cooperation and learning in real-life environments. Despite the effort of transferring and reorganising many of the courses to online learning environments, it was proven that such endeavours cannot replace the benefits of face-to-face learning. The temporary closure of the Governmental Network of Environmental Education Centers due to the restraining measures at the time constituted a critical factor hindering the successful ESD implementation. To minimize the impact of the nationwide restraining measures against the spread of COVID-19, UEESD offered mobile education programs whereby the exhibitions or the educational presentations were instead visiting schools on location. This initiative ran under the title "The Environmental Education Centers are Traveling to Schools". Schools had the opportunity to express their interest by selecting a specific program upon which non-formal educators would visit the schools and implement the corresponding program activities.

Engaging Methodologies and Strategies for EE & STEAM Education: In Greece

In the Greek educational system, environmental education is taught holistically through every subject of the curriculum that it could be linked with (Michaelides, 2005). Subjects that have to do with science are mostly the ones that can be connected to environmental education. But, despite that, mentions about the environment can be forwarded through the subject of Greek or even English language, in the form of writing a report or essay or through idea sharing on the subject. Environmental Education (EE) has been officially stated by legislation as mandatory in primary and secondary education (Global Environment Education Partnership, n.d.). Also, there is an individual subject that has been developed and is taught in the four grades of primary school titled "Study of the Environment". This subject is about the natural environment and living organisms, and thus it includes the topic of climate change (Michaelides, 2005).

EE in Greece can also be implemented voluntarily by every individual teacher, even if it is not mandatory by the curriculum, according to the different grades (kindergarten, primary school, secondary school). More specifically:

- Kindergarten students can be introduced to the subject of the environment through other lessons such as math, technology, language, etc.
- In primary school: Normally in grades 1 to 4 there is a designated time in the curriculum for the implementation of projects. Thus, the EE is implemented in this context supported by the project-based learning methodology. In grades 5 to 6 EE is connected again with other formal curriculum subjects such as geography.
- In secondary school: EE is based more on the voluntary participation of teachers. For example, teachers have the ability to create programs, after the completion of the school day, in which students can learn more about EE by doing projects, discussing, organizing extracurricular excursions, taking part in contests, etc. Parents' consent is needed, while teachers need to submit the program curriculum and outline to the responsible EE coordinator of the local Education Dictetorate. These programs incorporate the educational methods of project-based learning, inquiry-based learning and problem-solving (Global Environment Education Partnership, n.d.).

At the same time, in every Greek district, there are Centres of Environmental Education, that organize EE programs for primary and secondary school students. Those programs could include educational field trips to sites, museums, cities, parks, etc. They have a duration of one to two days and are outlined by the principle of sustainability. Teachers with a background in EE can take part with their students without charge since they are financially supported by the EU (Global Environment Education Partnership, n.d.).

In terms of sustainable mobility education, in Greece is mostly implemented through extracurricular projects developed by organizations, with the support and authorization of the Ministry of Education and Religion. A high-impact relative project in Greece is the "Sustainable Mobility Project" under the umbrella of the "Ecomobility Campaign". It is an initiative that aims to raise awareness among secondary education students about the subject of sustainable mobility and to educate them on different green mobility practices they can implement themselves. The project is supported and approved by the Greek Ministries of Education, Environment, Transportation and Infrastructure, Health, and Internal Affairs and Governance. One team of 8 students and 2 teachers participate in the project from every school (Ecomobility, 2021). The initiative utilizes the educational methods of project-based learning and problem-solving.

STEAM education is not officially included in the educational curricula in Greece, but there are plenty of private educational providers, institutions, schools, and organizations that are taking action for the

integration of STEAM into the teaching process. There are plenty of opportunities for the introduction of STEAM education to Greek students.

In the country experimental schools, teachers have the ability to create thematic educational groups. These groups have the purpose of introducing innovative and creative new tools to the educational process while introducing subjects that are not taught in the official curriculum. Many teachers in experimental schools and their students choose the subject of STEAM, STEM education and robotics. The Ministry of Education also organizes competitions and thematic contests that grant sponsorships and official licenses to the winning student teams.

Cooperation of higher educational institutions and Universities with schools can also promote STEAM education by the dissemination of knowledge and good practices (Sarlis & Papadakis, n.d.).

Limitations to the current methodologies and strategies used to teach about climate change, sustainable mobility and STEAM education

The use of the different engagement methodologies in Greece is a practice that has started developing in the last few years. This is why the bibliography concerning the gaps and overall results of the methodologies used in climate change, sustainable mobility and STEAM education is particularly limited. But, there are some gaps and limitations that have been identified by the use of the different engagement methodologies in general in the traditional educational system in Greece. For example:

It has been observed that the implementation of project-based learning is more effective in private schools rather than in public schools in Greece. This is because, according to research, in private schools teachers tend to be more professionally committed and willing to organize and participate with their students in various programs, like the ones mentioned before, or to implement various project-based learning activities themselves. In this context, in private schools, students also seem to be more eager to participate in such activities since they have more concrete learning objectives and expectations (Koutrouba & Alexaki, 2016).

Additionally, public schools in Greece seem to lack the necessary infrastructure or the organizational structure for the effective implementation of project-based learning activities. More specifically, again it is observed that private schools have more capacity for effective coordination and organization for the participation in projects and innovative educational activities (Koutrouba & Alexaki, 2016).

At the same time, according to the levels of students' satisfaction, it seems that when project-based learning is implemented into the traditional educational system, students feel uncertain about the way they are going to be assessed and express worry whether the teacher can make an objective assessment of them when they work in groups (Koutrouba & Alexaki, 2016).

Also, when teachers or educators implement the methodology of problem-based learning, they have to keep in mind that they need to present different subjects to each group of students, in order for the topic to be relevant to everyone. But this means that every group of students is going to be

introduced to different thematics and therefore acquire different knowledge backgrounds that cannot easily be identified as a whole (Aslanides & Gianelos, 2016).

In Ireland

There are several approaches that have been found to be particularly effective in engaging students in STEAM topics in Ireland. These include project-based learning, inquiry-based learning, and problem-based learning.

In Ireland, there has been a growing focus on these types of approaches, with many schools and educational institutions incorporating them into their teaching practices. For example, the Department of Education and Skills has supported the implementation of project-based learning through the Junior Cycle Framework, which encourages schools to incorporate interdisciplinary projects into their teaching.

In addition, there are several initiatives and programs in Ireland that focus on promoting these types of approaches. For example, the Bridge21 program, which is run by Trinity College Dublin, focuses on promoting collaborative and project-based learning in schools, and has been found to be effective in engaging students in STEAM subjects.

Overall, project-based learning, inquiry-based learning, and problem-based learning have all been found to be effective in engaging students in STEAM topics in Ireland and are increasingly being incorporated into teaching practices in schools and educational institutions.

Limitations to the current methodologies and strategies used to teach about climate change, sustainable mobility and STEAM education

There are some limitations and gaps in the current engagement methodologies and strategies used in Ireland for educating students on climate change, sustainable mobility, and STEAM education.

One limitation is the lack of consistent and standardized curriculum on these topics across all schools and educational institutions. While some schools have implemented climate change, sustainable mobility, and STEAM education into their curriculum, others have not, resulting in an uneven distribution of knowledge and skills among students. This can lead to gaps in knowledge and understanding, and limit the effectiveness of the educational efforts.

Another limitation is the lack of resources and training for teachers to effectively teach these topics. Many teachers may not have the necessary training or knowledge to effectively teach climate change, sustainable mobility, and STEAM education, which can limit the quality of education being provided to students.

There is also a lack of emphasis on the importance of these topics in the broader educational system, with some seeing them as peripheral rather than integral to the education system. This can result in a lack of support and investment in these topics, limiting their impact.

Finally, there may be a gap between the content being taught and the real-world context in which students will need to apply this knowledge. To address this, it is important to ensure that educational content is grounded in real-world scenarios and that students are given the opportunity to apply their knowledge in practical, real-world settings.

In terms of engagement strategies, it is important to recognize that not all students learn in the same way and that traditional teaching methods may not be effective for all students. Therefore, more innovative and diverse approaches need to be developed to engage and motivate students, including the use of digital tools and interactive learning experiences.

Overall, there are limitations and gaps in the current engagement methodologies and strategies used in Ireland for educating students on climate change, sustainable mobility, and STEAM education, and it is important to address these challenges to ensure that all students receive high-quality education in these areas.

In Netherlands

Project-based learning, Inquiry-based learning and Problem-based learning are some of the most effective approaches to STEAM education. Taking this into consideration, several projects in the Netherlands implement those approaches. These approaches align with the Dutch educational system as they promote active learning, student engagement, and the development of practical skills. They are often integrated into various subjects and disciplines, fostering collaboration, critical thinking, and creativity among students. Another important approach for STEAM education is the interdisciplinary approach that provides a deeper integration between various disciplines while those are still discrete. In that way, students can gain knowledge of the interconnections of the disciplines as well as valuable information about their interactions.

In particular, several initiatives involve teachers, school leaders and school communities to apply STEAM activities in cooperation with universities and other educational organizations. An example is the project STEAM it UP which aims to the development of 21st-century skills for students through an interdisciplinary approach with the use of technology and the project Generation AI which aims the development of key competencies and digital skills of teachers and learners through an interdisciplinary STEM approach. Finally, the Otter project that promotes Education Outside the Classroom integrated with STEAM subjects, the project aims to equip students with the necessary knowledge, skills, and attitudes to address environmental challenges and become active participants in creating a sustainable future.

Limitations to the current methodologies and strategies used to teach about climate change, sustainable mobility and STEAM education

Climate change education, STEAM education and sustainable mobility are priorities of the Dutch educational system. Nevertheless, there are some gaps in the strategies and methodologies that are currently used in the implementation of those subjects.

Climate change and sustainable mobility are complex and interdisciplinary topics and thus there is a necessity to use knowledge and skills from multiple disciplines in an integrative approach. While there are initiatives to incorporate climate change, sustainable mobility, and STEAM education into the curriculum, there can be challenges in ensuring a cohesive and integrated approach across different subjects. Sometimes, these topics are taught in isolation rather than being connected to other disciplines, which limits students' ability to see the interdisciplinary nature of these issues.

Teaching climate change and sustainable mobility through an interdisciplinary approach demands the use of competencies (knowledge, skills and attitudes) that integrate multiple disciplines with arts and social aspects. Traditional assessment methods may not fully capture the complex and applied nature of these subjects. There is a necessity to develop new assessment tools and adapt those that are already available to be able to evaluate skills such as critical thinking, systemic thinking etc.

A current challenge is to involve in designing and developing teaching materials that not all students learn in the same way as well as not all the students have access to the same resources. Ensuring inclusivity and diversity in the context of climate change, sustainable mobility, and STEAM education should be an important aspect.

Information and knowledge concerning climate change and sustainable mobility evolve rapidly, new technologies are rising in the 21st -century and there is a strong need to prepare students in a way that they can respond to those challenges. Therefore, educational methodologies and strategies need to be updated regularly to keep pace with new developments, scientific knowledge, and emerging challenges. Continuous adaptation and improvement are necessary to provide relevant and up-to-date education.

Taking into consideration the aforementioned gaps, teacher training is essential for effective education on climate change and sustainable mobility as well as for the building of their capacity to teach those subjects in an interdisciplinary STEAM educational approach.

In Portugal

The National Curriculum program foresees the implementation of project-based learning and experiment-leaning activities as the main educational methodology to teach environmental education. These activities also have a problem-based learning component, making them well-

rounded educational resources (Referencial, 2018). However, they seem generalized and insufficiently supported by a theoretical explanation and thorough description of the activities.

Parallelly, some innovative methodologies and strategies to engage young pupils in climate change learning are being tested locally. One of those was implemented in high school students and aimed to introduce arts and humanities into the climate change educational scenario. It promoted interdisciplinarity and a "in, with, and through art" approach to the subject (Bentz, 2020). Another one was implemented with primary students. Eco-feedback designs were introduced to children to test their perception of climate change. The study introduced emotionally persuasive icons (EPIs) to promote empathy in children and for the design of effective eco-feedback technologies. This methodology helped changed students' perception of climate change from an abstract concept to a more tangible one. It also leads to stronger engagement and emotional responses among children by increasing their empathy by linking actions to negative impacts towards known figures, like cats and dogs. This approach also envisions the digitalization of pedagogical resources (Dillahunt et. al., 2017).

Limitations to the current methodologies and strategies used to teach about climate change, sustainable mobility and STEAM education

Portugal currently faces many difficulties in its educational system. In 2022, 26.742 students were left without teachers. The situation persists in 2023, teachers' discontent with their professional situation has led to many strikes. Due to this educational crisis, the implementation of STEAM methodologies is predicted to fall short when compared to the rest of the EU community (Estudante, 2023; Hahn, 2023).

STEAM (or CTEAM in Portuguese) education is not very well known and doesn't gather consensus among experts. Many professionals in the education system are not familiarized with the concept. More commonly, methodologies employed are STEM and not STEAM since the inclusion of Arts in the curriculum brings two main concerns for the educators: 1) that it takes away time needed to teach mathematical and technological competences and 2) that it skims the pupil's awareness for the technicality and rigour required for the STEM areas. Many teachers also feel unprepared to create learning materials, teaching plans and implement STEAM interdisciplinary curriculums (Marques, 2023).

Environmental Education, where climate change and sustainability should be approached, hasn't evolved much since its implementation (Guerra et. al., 2008).

In regard to STEAM education, several limitations can be pointed. Some of the obstacles started in the implementation of the curricular guidelines for Science, Technology, Society and Environment (STSE), that are in line with a STEAM approach. The guidelines are perceived has overly general, vague, and open to multiple interpretations. Additionally, there are concerns about the extensive content and length of the documents, as well as issues regarding the adequacy of class hours and the alignment

with external evaluation and exams. Teachers have expressed the need for clearer articulation between different learning domains and better alignment with textbooks. Moreover, most teachers (73% of the inquiries) that the proposed curriculum is close to their practices prior to the curriculum and so, they have not substantially changed their teaching practices. Despite this, most teachers (56.9%) are open and consider adherence to the guidelines as relatively advantageous (Bonito & Oliveira, 2022).

Furthermore, since STEAM approaches are mostly used in classes focused on student competences development, outside of the traditional classes scope, teachers might feel unprepared to create resources, and lesson plans and to teach using an interdisciplinary approach. This can be an impediment whilst teaching specific competencies like climate change and sustainability that might be lectured by teachers from these fields. The lack of specificity in guidelines for the implementation of these curriculums is even more problematic in this case (Bonito & Oliveria, 2022).

STEAM Education for sustainable mobility & climate change

Best Practices: In Cyprus

Key enabling factors for the successful implementation of Climate Change Education (CCE) and Education for Environmental Sustainability (EES) for Cyprus on a policy level, reported in several national and UN publications, are discussed below. These have either directly or indirectly, partially contributed to creating the conditions for the successful engagement of students and the attainment of the desired learning outcomes.

The comprehensive, holistic, and unified policy approach targeting the EES implementation at all levels of education in Cyprus has proven to be an important measure of success. This overarching approach aimed to secure both consistency and continuity as well as limit the fragmentation risk of the various pursued actions. Two major components of this approach on an institutional level were: a) the inception of the National Strategic Planning for ESD touching upon issues surrounding the Curriculum, Training, Non-Formal Education etc., and b) the fact that all the individual policies and actions for ESD are implemented simultaneously and uniformly by addressing possible gaps, empowering the various actors in the process.

The establishment of the Unit of Education for the Environment and the Sustainable Development (UEESD) has been a major milestone for Cyprus in its endeavours to successfully implement ESD overseeing and pursuing to generate interconnections between ESD actions at the various levels of formal, non-formal and informal education. The Unit itself is responsible for designing, monitoring, updating and evaluating ESD at all levels of education. Importantly,

the UEESD is populated with staff with variant scientific backgrounds such as the natural sciences, education, humanities, the social sciences. This in itself enhances and secures a substantial level of interdisciplinarity on a collaborative as well as on a developmental level - a factor that contributes significantly to the promotion of actions and programs through which all dimensions of sustainability are addressed.

The establishment of the "Sustainable Environmental Education Policy of Schools" based on the whole-school-approach, as a mandate for pre-primary and primary education and as a "Unified School Plan for School-Self-improvement" in Secondary Education, is considered an important innovation since the schools tailor the programme according to their needs and priorities. Subsequently, this ensures ownership, and active involvement in all actions and changes in the school aiming to attain better sustainability levels while establishing the schools themselves as learning communities of environmental education.

The integration of non-formal education for ESD, as an official policy practice in the Cypriot education system, serves as a complementary structure in support of various ESD actions and initiatives undertaken by primary and secondary schools. Learning in these cases is transferred beyond the classroom, providing teachers and students with authentic learning experiences, helping them develop skills for research, field experimentation, observation, and action intervention, but also the development of multiple intelligences that are not easy to acquire through formal education. Another important factor for the successful implementation of ESD is financed from national resources. More than 1 million euros (excluding the expenditures of the staff salaries) is annually allocated for the implementation of ESD actions in Cyprus.

Lastly, the revision of the teachers' professional development programs based on the EES/ESD competence approach and the introduction of compulsory education and training programs for teachers and principals on EES/ESD, is also an important factor for the successful implementation of relevant initiatives and actions. Especially the professional development of teachers on a school basis is an important factor for the successful promotion of ESD actions at school because the support of teachers in ESD is based on their own needs, but also their students' and the school's needs in general. Also, the mandatory professional development of principals on ESD and especially for the promotion of the whole-school approach has proven crucial in securing effective learning conditions in schools.

The following are three best-practice examples utilising successful engagement strategies from various educational settings in Cyprus, addressing or touching upon climate change and sustainability in general.

1. PEDIA

In September 2020, the Cyprus Energy Agency in collaboration with the Ministry of Education, Sports and Youth, launched the European-funded program PEDIA, which allowed public schools in Cyprus to apply for the enhancement of their energy performance. The project duration is five years, between 2020 and 2025.

Out of 144 eligible schools, 25 were selected based on specific environmental, energy, educational and socioeconomic criteria. PEDIA project is the first project that approaches the overall needs of public school buildings in Cyprus, aiming to transform them into nearly zero-energy consumption structures. Currently, interventions are underway in five schools. The project aims to create a methodological precedence for tailored interventions specific to Cypriot public school buildings. The transformation of schools into green and sustainable infrastructures will be achieved through several interventions that include yet not limited to thermal insulation for roofs and walls, window replacement, installation of shading, ventilation, LED lighting, installation of photovoltaic systems, adoption of efficient solutions for cooling and the creation of green roofs. These transformations will highlight public schools as model examples in Cyprus and the rest of Europe, converting them into a vital pedagogical tool, helping their transition to a whole-institutional approach. In the overall process, students were engaged in the decision-making processes through an interdisciplinary project-based approach and exposed to a multiplicity of learning activities relevant to the structural and engineering interventions taking place in their school. To learn more about PEDIA check the following resources:

- www.moec.gov.cy/
- www.cea.org.cy/
- https://mepaa.moec.gov.cy/index.php/el/
- www.cea.org.cy/en/pedia/
- www.youtube.com/watch?v=Y7xvNyyg0h4
- www.facebook.com/PEDIAeuproject/

2. SDGs and Global Citizenship are travelling in a suitcase

The project emerged during the 2020 Pandemic. It is a comprehensive educational tool on the UN's Sustainable Development Goals. It consists of 17 books, each corresponding to the 17 SDGs, travelling in a "suitcase" to schools, neighbourhoods, businesses, communities, and various organizations. The aim is to inform, raise awareness, awaken, and mobilize each one of us to make the necessary changes that will improve the quality of life and create conditions for healthy, prosperous and sustainable societies. Each book has the following structure: 1) a brief presentation of the SDG along with its interconnections with the other SDGs; 2) 20 learning scenarios for each SDG and 3) activities developed for synchronous and asynchronous learning.

A simple tool that provides implementation instructions for each activity, additional sources of utilization, the means and resources required and alternative ideas for use. The innovation of this material is that it captures the SDGs cohesively as a whole, through activities that focus on learning to be, learning to live with others, learning by doing, learning by giving and sharing.

The material was finalized and integrated into the official Curriculum for ESD, helping the teachers and students to approach the SDGs holistically and interdisciplinary.

3. Making my school green, making my neighbourhood green

The project was based on the premise that schools, in collaboration with several stakeholders, can effectively help the mitigation of climate change through various actions. The fundamental idea of this initiative is to turn schools into "nursery gardens", whereby trees will signify the boundaries of schools instead of fences, and schoolyards will turn into small forests and botanical gardens. Students, parents, teachers and citizens that wish to help, will not merely plant the trees but will "adopt" and care for the garden created. In return, teachers will be equipped with the relevant skills and know-how as to how they can pedagogically utilize the newly formed gardens at their school. A coordination group will be created at each school, for the implementation and monitoring of the program. The group will consist of students, teachers, parents, and professionals, representatives from the corresponding communities, municipalities and school boards. The project aims to reinforce the green areas at the local level, contributing to the improvement of the microclimate, the increase of urban green areas, the development of volunteerism and the strengthening of environmental awareness and action through participatory processes. Basic components of the implementation of the project are, beside its environmental dimension to highlight its social and pedagogical aspects.

Best Practices: In Greece

We can identify a few key characteristics that activities about climate change, sustainable mobility and STEAM education should have in order to be effective and purposeful:

- Using active and innovative methods in order to increase the engagement of students,

- Making connections to issues and experiences that are relevant to students so they can better comprehend the subject,

- Engaging in open discussions in which students feel comfortable sharing their opinions and ideas,

- Inviting environmental scientists, experts on STEAM, or decision-makers in general, so they can interact with students and explain to them the scientific background of the subject,

- Clarifying and deconstructing any misconceptions or doubts that students have about each subject,

- Implementing projects or activities that involve the community or civil society in order to strengthen the feeling of belonging and collectivity (Monroe et al., 2017).

- The gamification of various educational tools in order to render the activities more playful and pleasing to younger primary or early secondary school students (Sipone et al., 2019).

In terms of practical examples of successful engagement strategies for EE and sustainable mobility education, two of them are described below.

1. Educational Games for Climate change

The Centre of Environmental Education Eleftheriou Kordeliou & Vertiskou has incorporated a practice of experiential learning into climate change education. More specifically, The Centre of Environmental Education has implemented the practice of educational games for climate change. Those educational games are an interactive and participatory approach to climate change education, since they encourage active learning and communication through dialogue while providing the opportunity of introducing to young students complex issues such as climate change. The games are created for students 12-15 years old but can be easily adapted to suit younger students as well. The Centre of Environmental Education Eleftheriou Kordeliou & Vertiskou provides an in-depth educational guide on how to implement the games in the classroom while giving tips to educators on how to better understand climate change education (Athanasiou et al., 2020).

2. Sustainable Mobility: "City with bikes – Beautiful City"

Retail shops "My Market" in cooperation with the Central Association of Municipalities of Greece (KEDE) have launched an innovative project titled "City with bikes – Beautiful City". It aims at encouraging the use of bicycles inside big cities as a form of sustainable mobility and it has already taken place in 19 Greek cities. Under the scope of promoting sustainable mobility, the initiative aims to educate "future bicyclists", students of the 4th, 5th, and 6th grades of primary school (Polychronopoulos, 2022). During their participation in the program, students get to make questions about sustainable mobility and the use of bicycles as a form of transportation and learn about the safety measures they have to keep in mind in order to stay safe while cycling. After the completion of the project, young cyclists get their first-ever bicycle license ("City with bikes – Beautiful City" by My Market, 2021).

In Ireland

There are several key factors that can contribute to successful engagement and learning outcomes in activities related to climate change, sustainable mobility, and STEAM education. These factors include:

- Active, inquiry-based learning: Active, inquiry-based learning activities allow students to engage with the material and explore new concepts in a way that is more meaningful and memorable. By taking a hands-on approach to learning, students can develop a deeper understanding of the subject matter.

- Interdisciplinary approach: An interdisciplinary approach to learning can help students see the connections between different subjects and understand the real-world implications of the concepts they are learning. For example, a STEAM education program could incorporate climate change and sustainable mobility topics into science, technology, engineering, math, social studies, and language arts curricula.

- Real-world relevance: Learning activities that are relevant to students' lives and the world around them can be more engaging and motivating. Students are more likely to become invested in the material if they can see its practical applications and real-world implications.

- Collaboration and teamwork: Collaborative learning activities can promote teamwork and cooperation among students, helping them to develop important social and communication skills. Working together on projects related to climate change, sustainable mobility, and STEAM education can also allow students to learn from one another and share their different perspectives.

- Teacher training and support: Teachers who are well-trained and well-supported are better equipped to engage students in learning activities related to climate change, sustainable mobility, and STEAM education. This includes providing professional development opportunities for teachers, giving them access to the latest resources and technology, and providing ongoing support and feedback.

- Community engagement: Engagement with the wider community, including parents, local organizations, and experts in relevant fields, can help to enrich students' learning experiences and provide real-world perspectives on the topics being studied.

By incorporating these factors into learning activities related to climate change, sustainable mobility, and STEAM education, educators can help to engage students and improve learning outcomes.

There are several examples of successful engagement strategies for topics related to climate change, sustainable mobility, and STEAM education in Ireland. Some of them are presented below.

1. Green-Schools Programme

The Green-Schools Programme is an international environmental education programme that encourages sustainable practices in schools and communities. In Ireland, the programme is run by An Taisce, an environmental organization. The programme focuses on a range of topics, including climate change, sustainable mobility, and waste reduction. Schools that participate in the programme work through a series of steps to achieve different levels of certification. The programme has been very successful in Ireland, with over 90% of schools participating.

2. Eco-Schools Programme

The Eco-Schools Programme is another international environmental education programme that focuses on sustainability in schools. The programme is run in Ireland by the Environmental Education Unit of An Taisce. Like the Green-Schools Programme, schools work through a series of steps to achieve different levels of certification. The programme covers a wide range of environmental topics, including climate change, sustainable mobility, and biodiversity.

3. STEAM Education Ireland

STEAM Education Ireland is a non-profit organization that aims to promote STEAM education in Ireland. The organization provides training and resources to teachers to help them integrate STEAM into their curricula. They also run workshops and events for students to engage them in STEAM activities. The organization has been very successful in engaging students in STEAM education and has received a number of awards for their work.

4. Smart-Travel Schools

Smart-Travel Schools is an initiative of the National Transport Authority that encourages sustainable mobility practices in schools. The initiative provides resources and support to schools to help them promote walking, cycling, and public transport. Schools that participate in the programme can achieve certification as a Smart-Travel School. The programme has been successful in promoting sustainable mobility practices in schools across the country.

In Netherlands

To ensure a successful and effective integration of learning outcomes in activities related to climate change and sustainable mobility using a STEAM educational approach, several strategies can be employed. These include:

- Enhancing cooperation and collaboration: Foster closer collaboration between universities, schools, and relevant stakeholders to create an effective teaching experience and establish meaningful connections with the community.
- Real-world problem emphasis: Focus on real-world problems and phenomena that allow students to engage with the complexity of the real world and apply their knowledge to address practical challenges.
- Utilizing digital technologies: Promote the extensive use of digital technologies, which enhance engagement and motivation, offer interactive learning experiences, and enable students to develop digital competencies.

- Adopting an interdisciplinary/transdisciplinary approach: Encourage an interdisciplinary or transdisciplinary approach to climate change and sustainable mobility education, promoting holistic thinking and the integration of various subject areas.

- Emphasizing social aspects: Increase students' awareness of the social dimensions intertwined with climate change and sustainable mobility, encouraging them to consider the societal implications, equity issues, and the importance of community engagement.

By implementing these strategies, educators can create a dynamic and engaging learning environment that effectively addresses climate change and sustainable mobility through the lens of STEAM education (Rousell & Cutter-Mackenzie-Knowles, 2020; Lehtonen et al., 2019).

Two notable examples of the implementation of the aforementioned key factors in the Netherlands are the STEAM it UP (https://steamitup.eu/en/) and Generation AI (https://generation-ai.eu/) projects. Both STEAM it UP and Generation AI exemplify implementation of interdisciplinary STEAM approaches in the Netherlands. By fostering collaboration, critical thinking, and the integration of new technologies, these projects contribute to a comprehensive and future-oriented education system that prepares students for the challenges and opportunities of the 21st century.

Finally, another noteworthy example is the Otter project (https://otter-project.eu/), an EU initiative aimed at promoting Education Outside the Classroom and enhancing students' scientific knowledge, engagement with STEAM subjects, and development as responsible citizens. The project recognizes the tangible benefits of the Education Outside the Classroom methodology, which involves a diverse range of activities such as field trips, visits to community and botanical gardens, museums, zoos, scientific centers, and engagement with digital learning platforms and media.

By implementing the Otter project, the primary goal is to increase students' awareness of planetary sustainability while fostering the acquisition of cognitive, affective, social, and behavioral skills. The project recognizes the value of experiential and immersive learning experiences in natural and community settings, as well as the role of digital technologies in enhancing educational opportunities.

Through the Otter project, students have the opportunity to engage in hands-on activities, interact with their environment, and develop a deeper understanding of the interconnectedness of ecological systems. By integrating Education Outside the Classroom with STEAM subjects, the project aims to equip students with the necessary knowledge, skills, and attitudes to address environmental challenges and become active participants in creating a sustainable future.

In Portugal

For the implementation of STEAM education in Portugal, experts state that the Portuguese curriculum is flexible enough to accommodate the STEAM approach through the establishment of areas of curricular autonomy. These domains allow for interdisciplinary work and the sharing of resources and strategies, which can facilitate the coexistence of STEAM and STSE dynamics. The freedom of teachers to choose appropriate pedagogical strategies and the involvement of higher education institutions and research centers in developing STEAM strategies also contribute to their integration. STS and STEAM approaches can be interconnected and coexist within the Portuguese educational context, both in formal and non-formal education settings. The flexibility of the curriculum and the collaboration between different stakeholders provide opportunities for the integration of these approaches in diverse learning environments (Bonito & Oliveira, 2022).

Previously mentioned initiatives like *Ciência Viva* have been quite successful in implementing environmental education and establishing partnerships between schools and institutions. These program contributed to improve students connection and understanding of nature. By scheduling field trips, students experience other learning context besides the classroom, moreover, they are exposed to real-life scenarios where they can engage in sustainable practices (Barba, 2023).

Case Studies

For this section of the E-Guide, national focus group were held, one for each partnering country.
A total of X teachers, educational authorities and environmental experts have joined the national discussions. The aim of these focus groups was to collect the strategies and challenges of teaching about climate change and sustainability XXXX.

Teaching Climate Change

In this section we collected the educational experts' inputs on the methodologies, curriculums and resources to teach about climate change, as well as strategies to keep students engaged.

Methologies for Climate Change Education: general findings

From the national focus groups, it was possible to find some common methodologies that are usually employed to climate change and environmental education. These pedagogical approaches are listed below:

1. **Experimental and Inquiry based Learning** - This approach involves taking students out of the classroom and into the field to conduct hands-on experiments and collect data related to climate change..Teachers encourage students to explore climate change topics through

questioning, investigation, and hands-on activities. This approach fosters critical thinking skills and allows students to discover and understand the scientific concepts behind climate change. This approach can be used in all educational settings, with students of all ages.

2. **Project and Collaborative based learning** - This approach involves students working collaboratively to develop and implement projects that address issues related to climate change. This approach can increase student engagement and motivation while also fostering critical thinking, problem-solving, and communication skills.

Other methodologies were pointed out has having the potential to be great approaches to teach environmental and climate change topics, however, they are currently not widely used in the educational systems. Some of these methods are here described:

1. **Service Learning** - This methodology combines community service with academic learning to create a more meaningful and real-world context for students. It can be used to address climate change issues by engaging students in activities such as community gardening or beach clean-ups, while also learning about the science behind climate change and its impacts.

2. **Place-Based Education** - This approach focuses on using the local environment and community as a context for learning about climate change. It involves engaging students in research, inquiry, and action related to climate change issues specific to their local area.

3. **Gamification** - This approach uses game-based activities and simulations to teach about climate change. This can be an effective way to engage students in learning about complex issues, increase motivation and interest, and provide an interactive and hands-on learning experience.

4. **Arts-based learning -** This methodology uses creative arts, such as music, dance, and visual arts, to teach about climate change. This can be an effective way to engage students who may be more interested in the arts, while also providing a creative and engaging way to learn about climate change issues.

Methodologies & Resources for Climate Change Education: In Cyprus

According to the views of the focus group participants, teaching methods and approaches appear to vary considerably among primary school teachers and secondary school educators, while to a lesser extent among the public and private sectors. Nonetheless, the greatest methodological variation is exhibited in comparing the formal and non–formal educational practices on a national level. These are mostly ascribed to curricular inflexibility and lack of adequate and extensive theme coverage concerning climate change and sustainable mobility characterising secondary education in Cyprus. Depending on each of the aforementioned

contexts as well as the personal educational philosophy of practices of teaching professionals these may include but are not limited to inquiry-based learning and project based learning, already describe and following national-specific approaches:

1. **Multidisciplinary Approaches**: Climate change is a complex issue that involves various scientific disciplines like Earth science, biology, chemistry, and environmental studies. Educators integrate these subjects to provide a comprehensive understanding of climate change. Used in the following education sectors: primary schools and non-formal education.

2. **Use of Technology**: Teachers employ educational technologies, such as interactive simulations, virtual labs, and multimedia resources, to enhance students' learning experiences and provide visualizations of climate change phenomena. Used in the following education sectors: primary schools and non-formal education.

3. **Climate Literacy**: Focus on developing climate literacy among students, ensuring they understand the fundamental principles of climate change, its causes, impacts, and potential solutions. Used in the following education sectors: primary schools and non-formal education.

4. **Current Events and Case Studies**: Incorporating real-world examples and case studies of climate change impacts on different regions and communities can make the subject more relatable and relevant to students' lives. Used in the following education sectors: primary schools and non-formal education.

5. **Environmental Stewardship**: Encouraging students to participate in eco-friendly practices, such as recycling, energy conservation, and reducing carbon footprints, helps them connect climate change awareness with personal responsibility. Used in non-formal education.

6. **Community Involvement**: Engaging with local communities or environmental organisations can provide students with opportunities to actively participate in climate change mitigation and adaptation efforts. Used in the following education sectors: primary schools and non-formal education.

7. **Guest Speakers and Experts**: Inviting climate scientists, environmentalists, or activists as guest speakers can offer students insights from professionals working in the field of climate change. Used in the following education sectors: secondary schools and non-formal education.

8. **Climate Change Debates**: Organizing debates and discussions on climate change-related topics can encourage students to critically analyse different perspectives and understand the complexity of the issue. Used in non-formal education.

9. **Global Perspective**: Emphasizing the global nature of climate change and its impact on diverse communities worldwide can foster empathy and a sense of shared responsibility among students. Used in all education sectors: primary schools, secondary schools, and non-formal education.

10. **Long-term Monitoring**: Involving students in ongoing climate monitoring projects or citizen science initiatives can provide them with a sense of contributing to real scientific efforts. Used in non-formal education.

11. **Art and Creativity**: Integrating climate change themes into arts and creative projects allows students to express their emotions and understanding of the topic in alternative ways. Used in all education sectors: primary schools, secondary schools, and non-formal education.

Both the application and effectiveness of these methods vary based on the student's age and prior knowledge, and cultural context taking into consideration the variant sociocultural and educational system differences exhibited between Greek Cypriot students residing in the controlled areas of the Republic and Turkish Cypriots residing in the occupied North. Based on their professional expertise, background and didactical proficiency educators will often combine or not multiple approaches to cater to the diverse needs of their students and ensure a well-rounded learning experience about climate change. Nevertheless, the number of educators applying these methods to their full extent and capacity is strikingly small. The predominant practices abide by traditional textbook methods of teaching.

Generally speaking, during the planning, development and implementation phase of a given content/activity, educators seek to inform their understandings as well as their students through an array of resources such as:

1. **National Curricula and Guidelines:** Use of the national curriculum guidelines that include topics related to climate change and environmental education. Educators often use these documents as a foundation for designing their lesson plans and selecting appropriate resources.

2. **Textbooks and Educational Material:** Educators utilize textbooks specifically designed for environmental studies, especially in primary school settings, or science subjects that cover climate change topics in-depth. These textbooks often provide structured information and activities for students to learn about climate change.

3. **Online Resources:** Teachers leverage various online platforms that offer educational resources, videos, interactive tools, and lesson plans related to climate change. These resources might include websites from governmental or non-governmental organisations, educational portals, and science-based platforms. Fol

4. **Educational Videos and Documentaries:** There are numerous documentaries and videos available on various online platforms or educational streaming services that address climate change topics in an engaging and informative manner. Educators use these videos to enhance their lessons and foster discussions.

5. **Hands-on Activities and Experiments**: Support interactive and hands-on learning, by incorporating hands-on activities and experiments demonstrating climate-related concepts and phenomena.

6. **Guest Speakers and Workshops:** Occasionally, educators invite experts in environmental science or climate change to give talks or conduct workshops in the classroom, offering students firsthand insights and experiences.

7. **Governmental and Non-Governmental Initiatives:** The Cyprus Pedagogical Institute (CIP) and numerous other community organisations offer educational materials and programs designed to promote climate change awareness and sustainability in schools. Below we list several such community organisations offering support with resources they developed in the context of EU actions & projects.

8. **Interactive Websites and Simulations:** Usage of various websites and platforms designed and developed in the context of EU-funded projects and initiatives offering simulations that allow students to explore climate change scenarios and understand the impacts of human activities on the environment.

9. **Climate Change Exhibitions and Events:** Educational visits and field trips to the several Environmental Education Centres in Cyprus operating under the supervision of CIP's Unit for Education for Environment and Sustainable Development (UEESD) exposes students to interactive and engaging learning environments and exhibitions related to climate change, environmental awareness and sustainability.

The UEESD provides a wealth of pedagogical, didactical and methodological material, resources and digital tools to support teachers and educators in their learning and teaching process. More specifically, the Unit has developed over the years the following resources, available in Greek Language:

- A Guide for primary teachers aiming to support the implementation of the curriculum for Environmental Education/Education for Sustainable Development touching upon matters of climate change. Learn more:

  http://archeia.moec.gov.cy/sd/557/odigos_efarmogis_programmatos_spoudon_perivallonti kis_ekpaidefsis.pdf

- A series of **12 educational online courses on Food Waste** which were developed under the European project "Life FoodPrint". The courses aim to inform, raise awareness, and educate students on issues pertaining to food production and waste, food safety, food waste management and reduction, composting, responsible consumption, and the adoption of sustainable practices to reduce food waste. The courses are designed to provide unique pedagogical learning experiences through games, quizzes and learning scenarios. They are offered on demand by ESD experts of the Unit on a school basis. However, this model training for students could be used by teachers to implement the full course of 12 modules at school, but also by students to learn at home.

- **Rethink** – 3 educational books in Greek with theoretical materials and educational ideas on actions, activities and measures that could be taken regarding waste management. Learn more: https://peeaad.schools.ac.cy/index.php/el/yliko/aporrimata

- Supportive additional material for teachers on Super User (2020) can be consulted on Annex A.

In addition, the Educational Environmental Centres of the Unit has developed WebTV, an online portal that includes audio-visual materials on educational actions, initiatives, and educational programs on sustainable development which were implemented in schools. WebTV aims to inform both students and teachers but also the general public on various topics related to sustainability and environmental issues in different geographical areas of the island. Learn more on: https://elearning.schools.ac.cy/index.php/el/monada-perivallontikis-ekpaidefsis

Besides this, the Unit's educational staff has developed lesson plans for teachers that correspond to each of the SDGs. These lesson plans are currently under production and once finalised will be packed in educational suitcases reaching out to more than 400 schools in Cyprus. This action, "SDGs and Global Citizenship are travelling in a suitcase" was nominated for a Distinguish prize at a European contest regarding SDGs and active citizenship.

Last but not least, another interesting educational resource is the YouTube animation videos created by groups of students from Primary and Secondary Education. These have been awarded during the competition of the environmental action "Creating for the 2030 Sustainable Development Goals"

(«Δημιουργώ για τους στόχους της Αειφόρου Ανάπτυξης 2030») touching upon issues of climate change and sustainable mobility. This action is the result of the collaboration of the Unit of EESD, the Pedagogical Institute of the Ministry of Education, Sports and Youth and the German Embassy in Cyprus. It was part of the 2020 German Presidency of the Council of the EU, aiming to inform and raise of European citizens' awareness, and especially young people, of Sustainable Development Goals. All videos are available in the link below:

https://www.youtube.com/watch?v=qOgAddPoVmc&list=PL3prVLKtEDPp5RQYefIVPwmDS2m Hg9Dq3

Methodologies & Resources for Climate Change Education: In Greece

The methodologies being used by participants for the implementation of climate change education in Greece are mostly teamwork, problem-based learning, and project-based learning. More specifically, participants shared that they have tried to implement practices such as planting trees and flowers at the courtyard of their schools, which is a project-based learning methodology, in order to teach students about the importance of taking care of the environment and introduce them to scientific concepts such as photosynthesis or the planting and preserving the soil process. Despite the effort though, those practices have not been registered as formal activities and therefore have not been implemented in a great scale or with great organization.

An example of problem-based learning used as a methodology for climate change education in Greece is the act of collaborating with several NGOs in order to locate and confront a specific environmental problem. In this context, students from Vocational Schools (schools in which teaching is based on providing practical and professional knowledge about specific specialties) cooperated with NGOs in order to collectively face and figure out ways to counter the problem of oils spills in the oceans.

Additionally, participants mentioned that some effective methodologies and activities they use in order to raise students' awareness about climate change are saving on electricity, using reusable water bottles, colour coordination of school litter (every colour corresponds to a different bin), composting, existence of gardens to cultivate vegetables, activities with the students about microplastics. Another project, that participants from an Experimental School mentioned, was about reusing textbooks instead of buying new ones each year, by having the students preserve them and thus reducing the use of paper. Also, there was a project according to which students have selected three beaches to analyze the percentage of microplastics and litter they found and proceed to clean them up.

The use of the STEM or STEAM methodology in Greece is not very popular because teachers are mostly incorporating climate change into the lesson which they have the capability of teaching according to the educational curriculum. But, in some cases, it is being used in order to facilitate climate change education. For instance, educators have tried incorporating the subject of climate change in sciences such as physics and math problems, statistics or chemistry.

Overall, the participants have identified that there is a gap in climate change education in Greece, as well as the lack of innovative methodologies to be implemented due to poor organization and formal collective action.

Taking into consideration the Greek educational system and the curriculum that has been developed, educators are only partially equipped to teach climate change in their classrooms. In most cases, the use of technology seems to be a powerful tool since it gives access to a plethora of information concerning climate change, which teachers in Greece can utilize in order to facilitate the subject. Also, some participants mentioned the use of technological educational games such as Kahoot in order to create quizzes in more fun and creative way for students to participate more actively. According to the curriculum, there is not a specific subject for climate change, but there are a few mentions of climate change incorporated into each existing subject. For example, in the subject of literature there are texts that have to do with climate change, which can be a great initiation to climate change education. At the same time, the Greek Institute for Educational Policy (IEP) has created the skills workshops. Those workshops are a collection of educational material for themes that are not fully covered by the official educational curriculum such as climate change. Thus, since educators have free access to this material, they can use it for climate change education in their classrooms.

There is room for improvement when it comes to modernizing and enhancing the resources provided to teachers. Sadly, it is not a given fact that all classrooms have access to technological tools such as computers, projectors, or speakers. So, firstly it is crucial that all schools across the country are equipped with the necessary technological instruments and have access to the internet. Additionally, the facilitation of education for climate change can be improved by the addition of innovative and creative educational methods and practices. For instance, participants suggested the use of social stories (for students that might have learning difficulties or ASD), of interactive learning and of educational videos that explain the concept of climate change in a plain and easily understandable manner. Lastly, it is important to pinpoint that educators in Greece feel that there is a plethora of extracurricular programs and projects related to climate change education that they can profit from, but sadly there is no time for their actual implementation.

Methodologies & Resources for Climate Change Education: In Ireland

The methodologies that are used in Ireland used to teach climate change in schools are: project-based learning, game-based learning and field-based learning.

In terms of resources used

There are several effective methodologies for teaching climate change that are not currently widely used in schools. Here are some examples:

- Textbooks and other written resources: These can include textbooks, articles, and other written materials that provide an overview of the science of climate change, as well as its impacts and possible solutions.

- Videos and other multimedia resources: Videos, animations, podcasts, and other multimedia resources can be used to engage students and provide a visual and dynamic way to learn about climate change.

- Data and visualizations: Graphs, charts, and other data visualizations can be used to help students understand the scientific data behind climate change and its impacts.

- Interactive simulations and models: Interactive simulations and models can be used to help students understand complex climate systems and explore the potential impacts of climate change.

- Hands-on activities: Hands-on activities such as experiments, field trips, and group projects can be used to engage students and provide a more active and participatory learning experience.

Methodologies & Resources for Climate Change Education: In the Netherlands

The methodologies currently used to teach climate change in schools from the Netherlands are based more practical and might seem more "informal". The approaches mainly focus on project based learning, collaborative learning and gamified resources.

In terms of project-based learning: In the PjBL approach, students are presented with a problem or issue strongly related to real-world problems concerning climate change. In the process of exploring and engaging with climate change, students learn the content and transversal skills that are required in teamwork, project work, and problem-solving.

In terms of resources typically used to teach climate change in schools they are as follows:

- Interactive graphs, real data, and raw data that can provide evidence to students on the phenomena that concern climate change

- Video experiments/interactive video experiments, hands-on activities, interactive simulations and models that can provide a great opportunity for students to investigate the concepts that concern climate change phenomena as well as the intrinsic complexity of climate change.

- Mobile applications, Video Games, and AR applications that can increase students' interest and engagement

- Concept maps or causal maps that can provide information on students' current understanding of climate change phenomena and complexity

- Textbooks, newspaper articles, governmental or intergovernmental resources, informative videos and other materials that can display the problem of climate change from a scientific or a societal point of view.

Methodologies & Resources for Climate Change Education: In Portugal

School education on climate change is still a novelty in Portuguese educational system. In terms of the mandatory curriculum, this topic is approached in the same that it was 10 years ago, despite the great progress that is being made in the field and the increased urgency to raise awareness towards it.

Books and manuals, of traditional teaching methods, are currently being updated and the updates might include a deeper approach to climate change however, currently the topic is approached ever so slightly. Participants were unsure if this action would bring enough innovation that climate change education needs.

To bridge the gap between these and other topics, a new class was created: Citizenship and Development. This class is mandatory for primary education (divided into three cycles, students ranging between 6 and 15 years old) and optional for secondary education (students between 15 and 18 years old). Some topics are mandatory lecturing, this includes sustainable development and environmental education however, there is no manual or other set resources to use, each teacher develops is own material and chooses how to implement it.

When asked what educational resources they used in their classes they were all forms of non-traditional resources. They mostly used experiment-based methodologies such as:

- Learning about climate change by understanding what acid rains and the consequences they have: in this experiment, teachers used a glass of tap and another with vinegar (pure or diluted) and then tested the effect of these liquids on several materials.

Other activities were mentioned but were implemented on a individual level – teachers developed and lectured the materials in their own classes.

In terms of resources, participants that are in active teaching disclaimed that they try to implement the teaching methodologies that they believe are useful to teach and raise awareness about climate change. Laboratory and field experiments along with text analysis and debates are some of the methodologies implemented however, all of them were unanimous about the lack of resources available. Once again, the implemented methodologies seem to be done on a personal level weren't of national implementation.

Manuals and books lack proper information about the issue and for interdisciplinary approaches, the resources simply don't exist. For the Citizenship and Development class, previously mentioned, teachers must develop their own content which can be problematic because the content is not uniform for all country students. The schools' level of engagement and education about climate change is also somewhat optional and dependent on the class coordinator's teaching field.

Because some of the class coordinators can be from several teaching fields such as: languages, history, science, maths, and arts, the developed resources must be simple and clear to promote engagement and understanding.

Since there are so few resources on climate change and other environmental problems, there is a pressing need to create them and not so much to improve them. Despite this, participants were unanimous about the need of teaching climate change as a concrete problem and not an abstract concept. With this in mind, they proposed teaching methodologies based on experimentation and field trips as a way to promote observational skills, critical thinking, communication, and creativity. Moreover, the use of simple blue-ribbon articles as a base to develop projects and hold debate – this activity would promote information literacy, collaboration, and communication skills. The articles could be worked by the pedagogic professional in order to ensure the text's adequacy to the pupil's age.

In addition to these activities, a good theoretical framework about climate change. On this subject, participants suggested that the resources should be created to provide simple, but accurate, information that is easy to understand for students with all interests, learning abilities, and socioeconomic and geographical background. The chosen approach should also raise awareness to the fact that science, climate change science in particular, are not exact and immutable. Young pupils need to understand that

that it is an estimate and science is always changing, not necessarily because the scientific community was wrong but because we are always learning more and getting more data. They believe is helpful to

show them that it is a learning process even for those who are experts in the area, and that they can also have a contribute to the matter. This would also foment scientific literacy in young pupils.

There is a clear void for environmental and climate change education resources and pressing need for them. Participants also disclamed that the combination of the researching and pedagogical worlds would bring useful and meaningful content that is needed.

Strategies for Engaging Students for Climate Change Education

General Findings

Effective strategies for engaging students for climate change education largely depend on demographic factors such as the students age, socioeconomic situation and preferred learning method. Overall, the focus groups suggested that interactive, hands-on activities usually are the most efficient in retaining students interest and attention. By acquiring practical knowledge on the effects of climate change or other environmental topics allows students to develop better and deeper understanding on the given topics.

National Findings

Engaging students for Climate Change Education: In Cyprus

Focus group participants have acknowledged that educational strategies and their associated effectiveness are largely dependent on the student's age group, cultural context and learning preferences. Moreover, the specific teaching style, didactic proficiency, pedagogical competencies, and overall experience of teachers utilising those are pivotal in effectively using and delivering these strategies and approaches. It is important to note that despite acknowledging these as particularly effective, participants admitted that these are hard to implement due to various hindrances (lack of available teaching time to allocate for this purpose, lack of support and time for preparation, lack of contextualised resources etc.):

1. **Hands-on and Experiential Learning:** Active learning experiences, such as field trips, experiments, and hands-on activities, help students tangibly connect with climate change issues. These experiences make the subject matter more relevant and memorable.

2. **Project-Based Learning:** Engaging students in long-term projects related to climate change allows them to explore the topic deeply, apply critical thinking skills, and collaborate with peers. This approach fosters a sense of ownership and motivation in their learning process.

3. **Interdisciplinary Approaches:** Integrating climate change topics into various subjects like science, geography, mathematics, and literature can help students understand the complexity of the issue and its interconnectedness with other disciplines.

4. **Inquiry-Based Learning:** Encouraging students to ask questions, investigate, and find answers about climate change fosters curiosity and develops their research and analytical skills. Teachers act as facilitators, guiding students to explore the subject matter actively.

5. **Use of Technology:** Leveraging technology, such as simulations, virtual reality, interactive websites, and online platforms, can make Climate Change Education more engaging and interactive for students.

6. **Local Relevance:** Connecting climate change issues to students' local environments and communities makes the topic more relatable and encourages them to take action at a personal level.

7. **Emotional Connection:** Presenting real stories and case studies about the impact of climate change on communities, ecosystems, and species can evoke empathy and emotional connection, making the issue more meaningful to students.

8. **Promote Student Voice:** Allowing students to express their opinions, concerns, and ideas about climate change empowers them and fosters a sense of agency in addressing the issue.

9. **Addressing Eco-Anxiety:** Climate change can cause eco-anxiety and distress in some students. Educators ought to create a safe and supportive environment where students can discuss their emotions and concerns related to the topic.

10. **Collaboration and Action:** Encourage students to collaborate on climate-related projects and engage in real-world actions like environmental campaigns, community initiatives, or participation in climate-related events.

11. **Continuous Learning:** Climate change is a complex and evolving topic - providing opportunities for ongoing learning and staying up-to-date with the latest research ensures students' knowledge remains relevant and accurate.

Established educational practices both in Cypriot primary as well as secondary school settings appear to fall both short and behind concerning student participation in the decision-making processes of Green Activities. The latter are mostly conceptualised and planned by teachers rather with minimal participation of students in terms of their ideation, management and later on execution. That being said, there are exceptions to these prevailing practices whereby students are provided with the opportunity to initiate and develop a given activity or an initiative, maintaining a leading role throughout the process.

Given those examples, participants acknowledged that involving students in decision-making processes for implementing Green Activities in a school is crucial as it not only empowers them to take ownership of environmental initiatives but also ensures that the initiatives are relevant and appealing to the student body. During the focus group discussion participants were asked to provide either exceptional practices they have encountered locally or an alternatively ideate hypothetical scenarios they felt could be of support to the engagement and participation of

students in such decision-making processes. Following are some examples they have provided which have further elaborated:

1. Create a Green Team: Establish a dedicated group of environmentally conscious students, known as the Green Team, to lead and promote sustainable initiatives. This team can act as a representative body for the student population and collaborate with school administrators and teachers on decision-making.

2. Hold Regular Meetings: Organize regular meetings with the Green Team to discuss ideas, plans, and progress on green initiatives. Encourage open communication, and ensure that each member has an opportunity to share their thoughts and suggestions.

3. Surveys and Feedback: Conduct surveys and seek feedback from the entire student body to understand their preferences, concerns, and ideas about green activities. This feedback will help tailor initiatives to match the interests and needs of the students.

4. Environmental Education: Conduct workshops or seminars on environmental issues to raise awareness and educate students about the importance of sustainability. Knowledgeable and informed students are more likely to actively participate in decision-making.

5. Brainstorming Sessions: Organize brainstorming sessions where students can come together to generate innovative ideas for green activities. Encourage creative thinking and collaboration during these sessions.

6. Student Representatives: Include student representatives from different grade levels on school committees or task forces related to sustainability. This ensures a diverse range of perspectives and promotes inclusivity.

7. Project-Based Learning: Integrate sustainability into the curriculum through project-based learning. This approach allows students to work on real-life green projects, applying their learning to tangible outcomes.

8. Competitions and Challenges: Organize eco-friendly competitions or challenges that encourage students to come up with practical green ideas. This fosters healthy competition and engagement.

9. Partnerships with Environmental Organizations: Collaborate with local or national environmental organizations to provide mentorship, resources, and guidance to students involved in green initiatives.

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10. Recognize and Celebrate Achievements: Acknowledge and celebrate the efforts and achievements of students involved in green activities. This recognition encourages further participation and motivates others to get involved.

11. Empower Student Leaders: Encourage student leaders within the Green Team to take on more significant responsibilities and delegate tasks to their peers. This fosters leadership skills and a sense of ownership.

12. Practical Implementation of Ideas: Whenever feasible, implement student-generated ideas. Seeing their suggestions come to life reinforces the importance of student involvement and participation.

13. Publicize and Share Progress: Keep the entire school community informed about the progress and impact of green activities. Use bulletin boards, newsletters, social media, and school assemblies to share updates and successes.

14. Continuous Improvement: Regularly assess the effectiveness of green initiatives and decision-making processes. Make adjustments based on feedback and outcomes to ensure continuous improvement.

Engaging students for Climate Change Education: In Greece

According to participants, there are a few strategies that have been proven effective in engaging students and most of them have to do with the connection to the natural environment. More specifically, educational exercises, excursions and outdoor activities in nature seem to be very beneficial for students since they calm down the students. Also, this way a connection is constructed between students and the environment, teaching them to be more mindful. In this context, another strategy that was mentioned is educational excursions in order to clean up public spaces such as beaches or archaeological sites. Through this exercise, students seem to gain insight on the consequences of climate change and irresponsible human behaviour. At the same time, it teaches students responsibility since they are the ones that have to clean up other people's litter for the sake of the environment. Another similar strategy is the encouragement of recycling inside the school premises. More particularly, one participant shared that in their school they teach the principles of recycling by engaging students in collecting recyclable material such as plastic bottles, bottle caps, paper, and storing them in the right recycling bins.

Additionally, educators in Greece tend to participate in various programs in order to facilitate climate change education, since it is not part of the official curriculum. In this context, one participant shared their experience running a program about active citizenship which incorporated climate change issues called "The Green Fund". The Green Fund aims at informing teachers and students about climate

change, introducing green concepts such as circular economy. When participating in this program students had the chance to create questionnaires concerning what they had learned in the program. They distributed those questionnaires to other students in their school in order to evaluate their knowledge on the subject. Afterwards, they created power point presentations in order to present their findings including charts and information tables to draw conclusions. As a continuation of this exercise, a visit was scheduled to the school from another gymnasium with the purpose of informing the new students what they had learned during the Green Fund program. This update was organized primarily by the students which took part in the program, giving them the opportunity to participate actively in the decision-making process and teaching them responsibility and accountability for their actions. Lastly, another suggestion for the engagement of students in the decision-making process is the creation of a School Environmental Team, which can be consisted of students and teachers for the coordination of environmental programs or the implementation of environmental policies in the school.

Another participant mentioned that in their school students' councils (five-member council and fifteen-member council) participate in the process of informing the school about the projects they have taken on (in their case a project about microplastics) and help with the decision-making process of activities such as recycling, gardening etc.

Engaging students for Climate Change Education: In Ireland

There are several strategies pointed out by the focus group participants for effective in engaging students in climate change education:

- Relate the issue to students' lives: Climate change can often feel like a distant and overwhelming problem to students. One effective strategy to engage students is to relate the issue to their own lives, by connecting it to their local environment, community, or personal experiences.

- Use interactive and hands-on activities: Engaging students in hands-on activities, such as experiments, field trips, and interactive simulations, can be effective in helping them understand the science of climate change and its real-world impacts.

- Provide opportunities for student-led inquiry: Allowing students to explore and investigate climate change topics on their own can be a powerful way to engage them in the learning process. This can be done through inquiry-based learning or project-based learning activities.

- Incorporate multimedia resources: Using multimedia resources, such as videos, infographics, and podcasts, can help students visualize and understand complex climate change concepts.

Involving students in the decision-making process of implementing green activities in the school can be a powerful way to engage them in sustainability and create a sense of ownership and responsibility over their environment. Here are some strategies that can be effective:

- Brainstorming sessions: Conducting brainstorming sessions with students can help generate ideas for green activities and initiatives. Encourage students to think creatively and come up with ideas that they are passionate about.

- Student-led committees: Creating student-led committees or eco-clubs can provide a space for students to take the lead on implementing green activities. Students can be responsible for researching, planning, and executing sustainability initiatives.

- Surveys and feedback: Soliciting feedback from students through surveys or focus groups can provide valuable insights into what green activities or initiatives students are most interested in. This can help guide the decision-making process and ensure that the initiatives are relevant to students.

- Classroom discussions: Incorporating discussions about sustainability and green initiatives into classroom lessons can help raise awareness and encourage students to get involved.

- Celebrate successes: Celebrating successes and recognizing the efforts of students who are implementing green activities can help motivate others to get involved.

By involving students in the decision-making process of implementing green activities in the school, you can help create a culture of sustainability and empower students to take action in their own lives.

Engaging students for Climate Change Education: In the Netherlands

Climate change is a complex and multi-dimensional issue that requires a comprehensive, interdisciplinary approach to fully understand its causes, impacts, and potential solutions. A monodisciplinary approach is insufficient for studying climate change and its effects. Instead, a holistic and systemic approach is essential for exploring the complex interactions within the Earth's climate system and for developing effective strategies for mitigating the impacts of climate change on ecosystems and human societies or adapting to them. Apart from teachers' content knowledge, it is also essential for them to have the ability to integrate knowledge and skills from multiple disciplines, as well as to negotiate the social, cultural, and ethical dimensions of climate change with their students. However, it can be challenging for teachers to effectively integrate knowledge and skills from multiple disciplines. Usually, teachers lack knowledge of climate change content and even though there are science teachers that possess extensive knowledge in these areas, report feeling underprepared to implement content beyond their expertise to fully address climate change science in their classrooms.

In order for teachers to be effectively trained in climate change education several areas should be considered:

- Knowledge of the scientific content: Teachers need to have a deep understanding of the scientific complexity of climate change such as the relationship between greenhouse gases and radiation in the atmosphere, the impact of fossil fuel combustion on greenhouse gas concentrations, and how the enhanced greenhouse effect affects Earth's energy balance.

Teachers must also be well-versed in future climate change projections, the development and interpretation of climate models, and the issues of uncertainty inherent in climate science. Additionally, they should possess a thorough understanding of the natural and human factors contributing to climate change, the expected consequences of rising global temperatures, and various approaches to climate change mitigation and adaptation.

- Awareness of the social aspects: In addition to the scientific complexities of climate change, there are also significant social, ethical, and cultural complexities to consider. This incorporates a holistic vision of the skills education should produce in students, and by extension, in teachers. These skills should include the ability to envision a sustainable future, to think critically and creatively, and to engage in collaborative problem-solving. They should also include an understanding of the social and ethical implications of climate change, such as issues of justice, equity, and human rights.

- Awareness of the teaching strategies for climate change education: Teachers are the facilitators who support students' exploration of climate change and empower them to take an active role. Teachers are necessary to be able to use a variety of strategies to facilitate student learning, including inquiry-based learning, problem-based learning, and interdisciplinary approaches. These approaches emphasize student engagement, real-world problem-solving, and connecting science to students' lives and communities.

- Ability to implement digital resources: Digital media has become a significant tool in climate change education and therefore is an important aeria for teachers' education. Examples of digital media teachers should be trained to make effective use of climate change teaching are gamification, web-based applications, and interactive digital simulations. Additionally, the use of virtual reality and augmented reality technologies can provide students with immersive experiences that allow them to explore and interact with different aspects of climate change.

- Ability to implement interdisciplinary approaches: Teachers' training should involve their development in implementing interdisciplinary activities. Climate change is a complex issue that touches on many different fields, from science to economics to politics. Interdisciplinary learning involves bringing together different subjects to help students understand the complex nature of climate change and the many factors that contribute to it.

There exist various approaches through which the training of teachers can become more accessible and efficient. A few examples of such measures are professional development programs that build teachers' capacity to implement activities that negotiate the scientific content of climate change, as well as the societal aspects of this topic. These programs typically involve a range of activities that are designed to equip educators with the necessary knowledge, skills, and resources to teach about

climate change effectively. Some examples of methods that could be followed in professional development programs are:

- Teacher academies: These academies often include workshops, seminars, and training sessions on climate science, the impacts of climate change, strategies for teaching climate change in the classroom, and resources for developing climate change-related lesson plans and activities. Additionally, teacher academies may provide opportunities for networking with other educators, collaborating on climate change education initiatives, and engaging with climate change researchers and experts.

- Mentoring: Mentoring can be a valuable component of teacher training and professional development in the area of climate change education, as it provides personalized support and guidance for educators who are working to integrate climate change into their teaching practice.

- Online courses and webinars: These are synchronous or asynchronous training programs that can be accessed online. They offer teachers the flexibility to learn at their own place and adapted to their own time resources, increasing accessibility.

Engaging students for Climate Change Education: In Portugal

In terms of learning about climate change, participants believe that interactive and observation or experiment-based methodologies work best for their students. Besides a good theoretical introduction to the topic, observational activities that allow the students to engage with nature and take their own conclusions about their surrounding world seem to increase students' engagement and interest in environmental and climate change education.

Using this experiment and observational-based methodologies some schools adopted trips to greenhouses or even created schools' gardens to promote students' understanding and connection to the environmental world. In these activities, students are exposed to organic farming and other sustainable techniques. This also transformed the developed activities into a project-based learning experience. In this line of learning, one school, that belonged to the *Ciência Viva* program, adopted different project-based methodologies every year like a green fashion-show, to promote sustainable behaviours and creativity, and other in collaboration with the school cafeteria where students weighted leftover as a way to promote food waste awareness.

Other school developed an activity that consisted in a field trip where students could observe a park's biodiversity, as a way to cultivate their knowledge and improve their skills and behaviours toward nature conservation. Additionally, they were challenged to find if the park was in good condition and if it was prepared to promote sustainable visits like the appropriate number of trashcans, drinking

founts, defined tracks to avoid plant trampling, and others. With this activity, it was also proposed for students to present their findings to municipalities with the aim to promote green advocacy, a sense of empowerment, and stimulating decision-making and analysis skills.

Despite these initiatives, they are locally developed and lack national implementation and uniformization.

Teachers: Training, Collaborations and Barries for Climate Change Education

General Findings

From the focus groups, the general consensus was that teachers have a crucial role in training and raising awareness about environmental problems for the future generations. Besides their importance, teachers stated that they don't feel sufficiently trained or equipped to lecture these topics in their classrooms. The fast-paced educational systems that are being pushed by EU to reform and innovate the educational system, lack clear strategies and resources on a practical and local level. The past Covid-19 pandemic has also highlighted the importance of innovating the educational systems however, these changes were very abrupt. Many teachers were pushed to implement digital educational resources without previous training or support. Additionally, the isolation measures of the pandemic prevented experimental-based learning activities that, as previously stated in this document, was an unanimously successful strategy to improve students engagement in climate change education. Key action points for improve teachers training in climate change education are as follows:

1. Deepening Subject Knowledge

Climate change is a complex and multifaceted topic that requires a solid understanding of scientific concepts, environmental issues, and social implications. Teacher training programs provide educators with up-to-date and accurate information about climate change, its causes, consequences, and potential solutions. This ensures that teachers can confidently address students' questions and misconceptions, fostering a strong foundation for learning. Several teachers and educators mentioned that CPI training courses often assume a background knowledge, experience and understanding of fundamental didactic and content-related concepts effectively rendering these opportunities hard to follow by many.

2. Developing Pedagogical Skills

Effective teaching of climate change requires using appropriate teaching methods, strategies, and resources to engage students effectively. Teacher training programs help educators develop pedagogical skills specific to Climate Change Education, such as using real-life examples, hands-on

activities, multimedia resources, and collaborative learning techniques. These methods make the subject more relatable and meaningful to students.

3. Addressing Controversial Topics

Climate change can be a contentious subject, and some students and parents may hold diverse viewpoints or even deny its existence. Teacher training equips educators with the tools to handle sensitive and controversial topics in the classroom. This includes promoting respectful discussions, encouraging critical thinking, and presenting scientific evidence in an unbiased manner .

4. Incorporating Interdisciplinary Approaches

Climate change is not just a scientific issue; it also involves social, economic, and ethical dimensions. Teacher training can help educators incorporate interdisciplinary approaches in their lessons, allowing students to explore climate change through various lenses, such as geography, economics, ethics, and policy.

5. Promoting Climate Literacy

Teacher training emphasizes the importance of fostering climate literacy among students. This involves helping students understand the scientific principles behind climate change, its impact on ecosystems and communities, and the actions individuals and societies can take to mitigate its effects. Climate-literate students are better equipped to become responsible citizens and make informed decisions in the future.

6. Encouraging Environmental Stewardship

Effective Climate Change Education goes beyond just imparting knowledge; it also aims to instil a sense of environmental stewardship in students. Teacher training helps educators devise activities and projects that encourage students to take action, such as reducing their carbon footprint, promoting sustainable practices, and advocating for environmental protection in their communities.

7. Supporting Professional Growth

Teacher training programs offer opportunities for professional development, allowing educators to stay updated on the latest research, teaching methodologies, and educational resources related to climate change. Continuous professional growth ensures that teachers remain motivated, inspired, and better equipped to engage students effectively.

In terms of partnerships and collaborations, most participants stated that it not a common practice. Even though they recognize the benefits and impacts of involving different stakeholders in climate change education, lack of time and processes prevents it from becoming a more common practice. Most develop their own curriculums and programmes and at must, collaborate with other schools teachers to develop school-based activities. Some, developed punctual environmental activities with local municipalities.

National Findings

In Cyprus

Teachers Training

Focus group participants unanimously acknowledged the crucial role of teacher training in ensuring the effective teaching of climate change in schools. By equipping educators with the necessary knowledge, skills, and resources through teacher training programs - one can subsequently foster an environment where students can engage meaningfully with the subject matter. The discussion revealed several ways through which teacher training contributes to effective teaching of climate change in schools.

In conclusion, teacher training plays a vital role in promoting effective teaching of climate change in schools. By providing educators with subject knowledge, pedagogical skills, and interdisciplinary approaches, teacher training programs empower teachers to create engaging and impactful learning experiences for students, shaping the next generation of environmentally conscious citizens.

The Cyprus Pedagogical Institute (CIP) constitutes the national agency in Cyprus mandated with the responsibility of providing professional development opportunities to teachers. However, teachers' in-service training on Education for Sustainable Development (ESD), and subsequently for climate change, falls under the responsibility of the Unit of Education for the Environment and Sustainable Development (EESD). All compulsory and optional courses on ESD competencies for teachers, principals and other educational stakeholders have been revised since 2016 to follow the teachers' ESD competence of UNECE and the RSP ESD competence model, which is a developed form of UNECE competencies.

Nevertheless, our focus group participants have raised issues of both accessibility as well as the effectiveness of these courses highlighting the disconnect between theory and realistically implementable practice. The majority has expressed strong views surrounding the numerous ground reality challenges and limitations on the effective implementation of recommended activities, actions and initiatives both in a classroom as well as on a school level. The theoretical framework provided by EESD alongside the numerous resources offered (despite these being relevant, comprehensive and innovative) presupposes a level of organisational support and infrastructure to teachers that is either inexistent or undeveloped in the Cypriot educational context. Overloaded schedules, burned-out educators, lack of support and adequate time to allocate to initiatives and supplementary actions supportive of Climate Change Education - are just a few of the most pressing challenges identified by the participants.

In light of the above though the discussion was steered in such a way aiming for participants to identify strategies that could render UEESD trainings more accessible and effective for improving the quality of education and supporting teachers in their professional development. The following strategies have either been proposed or deduced by the report writer based on the suggestions made by the group:

- **Online and Blended Learning:** Provide teacher training programs through online platforms, allowing educators to access resources and courses from anywhere at their convenience. Blending online and in-person components can create a flexible learning experience while maintaining the benefits of face-to-face interaction.

- **Mobile Apps and Microlearning:** Develop mobile applications and microlearning modules that offer bite-sized content, making it easier for teachers to learn in short bursts whenever they have a few spare moments.

- **Customisation and Personalization:** Offer personalised learning pathways based on teachers' individual needs and strengths. Recognise that not all educators have the same level of expertise or face the same challenges, so tailored training can be more effective.

- **Peer Learning and Collaboration:** Encourage collaborative learning among teachers. This can be facilitated through online forums, workshops, or group activities where educators share ideas, experiences, and best practices.

- **Practical and Real-World Applications:** Ensure that teacher training focuses on practical skills and strategies that can be directly applied in the classroom. Use case studies, simulations, and real-world scenarios to make the training relevant.

- **Mentorship and Coaching Programs:** Establish mentorship and coaching initiatives where experienced teachers support and guide new or less experienced educators. This ongoing support can significantly impact a teacher's growth and effectiveness.

- **Formative Assessment:** Implement formative assessment throughout the training process to identify areas of improvement and adapt the training accordingly. Regular feedback helps teachers gauge their progress and reinforces their commitment to learning.

- **Incorporate Technology and Multimedia:** Use multimedia resources like video demonstrations, interactive simulations, and virtual classrooms to enhance engagement and understanding of complex teaching concepts.

- **Recognition and Incentives:** Recognize and reward teachers who actively participate in professional development and show improvement in their teaching practices. Incentives can motivate educators to invest time and effort in their continuous growth.

- **Collaboration with Education Institutions:** Partner with universities and colleges to integrate teacher training into pre-service education programs, ensuring novice teachers develop the relevant skills early on.

- **Accessible Cost Structures:** Make sure that teacher training programs are affordable or free, especially in regions with limited access to quality education resources.

- **Support from School Administrators:** Involve school administrators in the teacher training process, as their support and understanding of the training's importance can positively impact teacher participation and implementation of new techniques in the classroom.

- **Long-term Commitment:** Understand that teacher training is an ongoing process. Support teachers throughout their careers by providing continuous professional development opportunities.

- By employing these strategies, teacher training can become more accessible, relevant, and effective, resulting in better-prepared educators who can create positive learning experiences.

Collaborations & Partnerships

In terms of stakeholder and community engagement, it varies extensively across the Cypriot educational landscape. In the experience of our focus group participants, such actions are predominantly managed centrally by the Ministry of Education, Sport and Youth (MOESY) and the Cyprus Pedagogical Institute (CIP) through formally issued school guidelines. Alternatively, and to a much lesser extent, decentralised actions and initiatives are managed on a school level or by individual teachers.

In the light of the former, centralised courses and seminars offered by the CPI encompass pieces of training, seminars, festivals, interactive experiences and educational resources to various groups of the society, such as parents, non-formal education trainers, NGOs, ministry officials and policy-makers from various ministries, local authorities, embassies, staff members of various European organisations and many more. A mere example of such an action was CIP's effort to develop an educational material corpus alongside non-formal education activities (e.g. experiments, games, lists of free online books) in collaboration with the Pancyprian Association of Parents. This collaboration led to the development of these resources made available to parents and their children pursuing informal educational

activities at home. These proved particularly valuable and effective during the COVID-19 school closure. This content can be viewed in the Greek Language in the link provided: https://mepaa.moec.gov.cy/index.php/el/epimorfosi/yliko-gia-goneis

In Cyprus, numerous of actions have led to successful school community initiatives - one of the most important centralized and successful initiatives running since 2013 is "Tiganokinisi' (in Greek, Τηγανοκίνηση). It constitutes an educational, environmental program focusing on the collection and recycling of used cooking oil. The programme itself kicked off in 2011 on a pilot basis and since 2013 it has been adopted and integrated into schools across the island, reaching more than 455 education units all over Cyprus. Through this program, students learn how used cooking oil can be transformed into biodiesel while participating schools gain resources (funding) for environmental education and support in favour of their environmental infrastructure. The general public, as well as the hospitality industry, have supported this endeavour all throughout, by collecting used cooking oil resulting from frying and cooking and passing it on to students of their neighbourhood delegated to gather it at school for further collection. Further information for this action can be found here: http://www.tiganokinisi.eu/

The focus group participants did not have the chance to engage personally in large-scale decentralised stakeholder engagement initiatives in the recent past, nor were they aware of the particularities governing examples of effective practices of successful actions they happened to be aware of.

Challenges & Barriers

Teaching climate change can be a rewarding experience for both teachers and students, as it addresses a crucial global issue. However, educators may face several challenges in their effort to address and incorporate them into their daily teaching practice. Some of the main challenges identified by the focus group participants, relevant to the Cypriot educational context, relate to the:

- Lack of resources for secondary education: Teachers may struggle to find appropriate, up-to-date, and comprehensive resources to effectively teach about climate change. Participants suggested that resources offered by CPI often require extensive adjustments and down-scaling to be rendered applicable in their classroom. Moreover, the disproportionate emphasis on primary school content development by CPI limits substantially the resource arsenal of secondary school educators. Subsequently, this forces them to develop original content which requires further time and effort on their behalf, the luxury of which they do not enjoy.

- Lack of adequate curricular emphasis: The allocated teaching time for climate change and environmental education in secondary schools in Cyprus is alarmingly and disproportionately minimal compared to other EU member states. As a result, the incorporation of activities or related themes is left at the discretion of educators who exhibit a vested interest in the topic.

- Complexity and interdisciplinary nature: Climate change is a multifaceted issue that spans multiple scientific disciplines, including climate science, ecology, geology, and more. Integrating these different aspects into a coherent and understandable framework can be challenging for educators. Teaching professionals with relevant backgrounds or expertise in the field of Environmental Education within the broader educational landscape in Cyprus are few. Consequently, the responsibility of delivery of Climate Change Education is trickled down to teaching practitioners who are neither adequately informed nor trained. More often than not this discourages them from allocating the necessary teaching time or compromises the quality of delivery of the lessons they prepare.

- Time constraints: Limited classroom/teaching time and lack of available time for activity development on teachers' behalf - are probably the two most persisting and systemic challenges of the Cypriot educational system, sabotaging the well-intended efforts of the majority of educators. time. Yet classroom/teaching time is essential to meaningfully touch upon the vast and multifaceted topic of climate change. Similarly, finding effective and engaging ways to deliver the subject, to tailor its content and language to suit the age and cognitive requirements of students can be a disconcertingly time-consuming and labour-intensive task.

- Inadequate teacher training: Not all educators may have received sufficient training or professional development opportunities to teach climate change effectively. This can hinder their ability to deliver the subject matter in an engaging and informed manner often generating misconceptions among students.

- Controversy, scepticism and lack of awareness: Climate change is a polarizing topic, with some individuals denying or downplaying its significance. Teachers might encounter resistance from headmasters and principals, colleagues, parents, students, or even school administrators who have differing beliefs or are influenced by misinformation. This can create challenges for teachers who wish to develop and implement relevant school initiatives.

In light of the previously identified challenges and barriers regarding Climate Change Education, specific to the Cypriot educational context, the focus group participants suggested the following best practices and effective strategies. In their recommendations and suggestions, they were prompted to focus on applicable strategies which were fundamentally and at large unrestrained to systemic dependencies - in other words avoiding suggestions about actions that ought to be taken by external and centralised entities such as the CPI and the MOESY in support of educators. Instead, they were asked to propose emancipatory, decentralised and school-community manageable strategies.

In Greece

Teacher Training

In Greece, teacher training on climate change education is inadequate, even though there are some trainings being implemented mostly in secondary education. More emphasis should be put on equipping teachers with the necessary knowledge on how to promote climate change education and on which tools they can implement during the teaching process. The participants highlighted the importance of those trainings in order to learn all the different ways they can incorporate climate change into their subject, despite the fact that climate change is not a subject of its own in the Greek educational system. Not only that but some suggested the implementation of trainings not only for the teachers but for the parents as well. Parents are actively included in their child's education and pedagogy. Thus, it is important that they also have substantial knowledge of climate change and of what they can do in order to teach their children the basic environmental principles, in accordance with their school education. Additionally, in the context of teacher training seminars, participants suggested the creation of a teacher forum. This forum would have the purpose of sharing good practices and knowledge between schools and thus creating a shared space for teacher communication.

The most important aspect of the teacher training seminars should be that they are free and accessible to all teachers who are seeking to enhance their knowledge on climate change education, without being an extra financial burden on them.

Collaboration and Partnership

The majority of participants mentioned that they do not typically engage parents or many different stakeholders when implementing projects or activities about climate change. Although, one of the participants pinpointed that they are in cooperation with the local community for the implementation of a beach-cleaning project. In the context, the students cooperate with the local community also in the level of informing the public about their work and their findings.

Challenges & Barriers

The main challenges of teaching climate change in Greek schools have to do with the lack of resources, staff and time. More specifically, it is evident that many Greek schools are not only understaffed but the teachers also do not acquire enhanced knowledge on climate change, and thus are not deemed fully equipped to individually teach this subject. Also, the lack of time is a great challenge to most educators. That is because they are required by the educational curriculum to cover certain thematics in a specific time frame, which is restricting by itself. So, adding the requirement of implementing or participating in extracurricular programs about climate change is an additional burden for them.

The lack of modernized technological tools and resources is also a great challenge that obstructs climate change education in Greece. At the same time, even though some practices are implemented in a smaller scale individually in certain schools, those are not formally registered and thus their implementation is taking place empirically and with little organization. Another crucial barrier educators in Greece face when talking about climate change is the lack of knowledge and information of students on the subject. Greek students are inadequately informed about the different aspects of climate change and thus they are not aware of the scale of this phenomenon. Overall, Greek students do not comprehend how climate change affects them and why they need to act independently and collectively for the preservation of the planet.

In Ireland

Teacher Training

Teacher training is essential for effectively teaching climate change education in schools. Teachers are the primary facilitators of learning in the classroom, and they play a critical role in shaping students' understanding of complex and often contentious topics such as climate change. As such, it is essential that teachers have the knowledge and skills needed to effectively teach this subject.

For the irish teachers, the ways to in which teacher training can be made more accessible and effective in educating students on climate change also fall under the categories pointed previously:

- Online Training: Providing online training sessions can help make it more accessible for teachers, especially those who have difficulty attending in-person training sessions. This mode of training can be more flexible and self-paced, allowing teachers to complete it on their own time.
  Professional Development Programs: Schools and educational institutions can also provide professional development programs to help teachers enhance their skills and knowledge in teaching climate change. These programs can include workshops, seminars, and conferences that offer hands-on experience, new ideas and resources, and opportunities to collaborate with other educators.

- Collaboration: Teachers can also collaborate with environmental organizations and agencies to share resources and expertise, providing support in teaching climate change. Such collaboration can provide teachers with valuable insights and experiences that they can apply in   the   classroom.

- Incentives: Offering incentives, such as financial compensation or recognition, for teachers who complete climate change education training programs can motivate them to participate and make the training more effective.

- Curriculum Integration: Integrating climate change education into the curriculum can help make teacher training more effective. This will provide teachers with a clear understanding of what to teach and how to teach it, ensuring that the education is consistent and up-to-date.

Collaboration and Partnership

Challenges & Barriers

Some of the main challenges that teachers may encounter when teaching climate change in schools include:

- Controversial nature of the topic: Climate change can be a politically charged topic, and some students or their families may have different beliefs or opinions about the causes and effects of climate changes

- Lack of resources: Teachers may struggle to find appropriate and engaging resources to use in their lessons, including relevant and up-to-date materials, videos, and interactive activities.

- Limited time: Teachers often have a lot of material to cover in a short amount of time and may not be able to allocate sufficient time to teaching climate change.

- Difficulty of the subject matter: Climate change can be a complex and abstract topic, which may be difficult for students to understand, particularly at younger ages.

- Overemphasis on the negative: Climate change is a serious issue, but a focus solely on the negative aspects can be overwhelming or demotivating for students. It's important to balance the information with positive actions and solutions that can make a difference.

There are several strategies that can be effective in addressing challenges and barriers in teaching climate change in schools.

One strategy is to use interactive and participatory teaching methods that actively engage students in the learning process. This can include using visual aids, case studies, and group discussions to help students connect with the material and understand the relevance of climate change to their lives. Another effective strategy is to incorporate real-world examples and local issues into the curriculum, which can help students see the immediate impacts of climate change on their community and build a sense of urgency to take action.

It can also be helpful to collaborate with other teachers, schools, and community organizations to share resources, best practices, and ideas. This can help to build a stronger network of educators and advocates who can work together to raise awareness and inspire action on climate change.

Additionally, providing ongoing professional development opportunities for teachers can help to address challenges and build capacity for effective climate change education. This can include workshops, webinars, and other forms of training that provide teachers with the knowledge, skills, and resources they need to teach about climate change in an engaging and effective way.

Finally, creating a supportive school culture and involving parents and the wider community in climate change education can help to build momentum and sustain efforts over the long term. This can include engaging students in school-wide initiatives, hosting community events, and involving parents in decision-making processes around sustainability and climate action.

In the Netherlands

Teacher Training

Climate change is a complex and multi-dimensional issue that requires a comprehensive, interdisciplinary approach to fully understand its causes, impacts, and potential solutions. A monodisciplinary approach is insufficient for studying climate change and its effects. Instead, a holistic and systemic approach is essential for exploring the complex interactions within the Earth's climate system and for developing effective strategies for mitigating the impacts of climate change on ecosystems and human societies or adapting to them. Apart from teachers' content knowledge, it is also essential for them to have the ability to integrate knowledge and skills from multiple disciplines, as well as to negotiate the social, cultural, and ethical dimensions of climate change with their students. However, it can be challenging for teachers to effectively integrate knowledge and skills from multiple disciplines. Usually, teachers lack knowledge of climate change content and even though there are science teachers that possess extensive knowledge in these areas, report feeling underprepared to implement content beyond their expertise to fully address climate change science in their classrooms.

In order for teachers to be effectively trained in climate change education several areas should be considered:

- Knowledge of the scientific content: Teachers need to have a deep understanding of the scientific complexity of climate change such as the relationship between greenhouse gases and radiation in the atmosphere, the impact of fossil fuel combustion on greenhouse gas concentrations, and how the enhanced greenhouse effect affects Earth's energy balance. Teachers must also be well-versed in future climate change projections, the development and interpretation of climate models, and the issues of uncertainty inherent in climate science. Additionally, they should possess a thorough understanding of the natural and human factors contributing to climate change, the expected consequences of rising global temperatures, and various approaches to climate change mitigation and adaptation.

- Awareness of the social aspects: In addition to the scientific complexities of climate change, there are also significant social, ethical, and cultural complexities to consider. This incorporates a holistic vision of the skills education should produce in students, and by extension, in teachers. These skills should include the ability to envision a sustainable future, to think critically and creatively, and to engage in collaborative problem-solving. They should

also include an understanding of the social and ethical implications of climate change, such as issues of justice, equity, and human rights.

- Awareness of the teaching strategies for climate change education: Teachers are the facilitators who support students' exploration of climate change and empower them to take an active role. Teachers are necessary to be able to use a variety of strategies to facilitate student learning, including inquiry-based learning, problem-based learning, and interdisciplinary approaches. These approaches emphasize student engagement, real-world problem-solving, and connecting science to students' lives and communities.

- Ability to implement digital resources: Digital media has become a significant tool in climate change education and therefore is an important aeria for teachers' education. Examples of digital media teachers should be trained to make effective use of climate change teaching are gamification,web-based applications, and interactive digital simulations. Additionally, the use of virtual reality and augmented reality technologies can provide students with immersive experiences that allow them to explore and interact with different aspects of climate change.

- Ability to implement interdisciplinary approaches: Teachers' training should involve their development in implementing interdisciplinary activities. Climate change is a complex issue that touches on many different fields, from science to economics to politics. Interdisciplinary learning involves bringing together different subjects to help students understand the complex nature of climate change and the many factors that contribute to it.

There exist various approaches through which the training of teachers can become more accessible and efficient. A few examples of such measures are professional development programs that build teachers' capacity to implement activities that negotiate the scientific content of climate change, as well as the societal aspects of this topic. These programs typically involve a range of activities that are designed to equip educators with the necessary knowledge, skills, and resources to teach about climate change effectively. Some examples of methods that could be followed in professional development programs are:

- Teacher academies: These academies often include workshops, seminars, and training sessions on climate science, the impacts of climate change, strategies for teaching climate change in the classroom, and resources for developing climate change-related lesson plans and activities. Additionally, teacher academies may provide opportunities for networking with other educators, collaborating on climate change education initiatives, and engaging with climate change researchers and experts.

- Mentoring: Mentoring can be a valuable component of teacher training and professional development in the area of climate change education, as it provides personalized support and guidance for educators who are working to integrate climate change into their teaching practice.

- Online courses and webinars: These are synchronous or asynchronous training programs that can be accessed online. They offer teachers the flexibility to learn at their own place and adapted to their own time resources, increasing accessibility.

Collaboration and Partnership

_Several strategies can promote the involvement and engagement of different stakeholders in climate change education initiatives, some examples of which are:

- Elaboration on common projects with the local community: Collaboration between different stakeholders, including educators, community members, local schools and universities, can

help to promote a shared understanding of climate change and encourage the development of effective education initiatives.

- Use of social media: The utilization of social media platforms can aid in the expansion of the audience and promotion of engagement with climate change education initiatives

- Public campaigns: Public campaigns have the potential to enhance the awareness of local communities regarding specific issues related to climate change, thereby instilling a sense of concern among the community.

- Increase inclusiveness in collaborative initiatives: Incorporating inclusive and culturally responsive practices into climate change education initiatives can help to engage diverse audiences and promote equity in groups.

- Volunteering initiatives: Volunteering initiatives can provide opportunities for parents and other stakeholders to invest their time in community projects related to climate change.

Some effective strategies and resources concerning building and sustaining partnerships for climate change education in schools are the following:

- Collaborating initiatives: Collaborating initiatives between different stakeholders, including educators, community members, policymakers, and scientists, can help to promote a shared understanding of climate change and encourage the development of effective education initiatives.

- Open schooling: Through open schooling, cooperation is developed between enterprises, universities, and communities, in order for students to work with real-life problems to develop the competencies that they need to ensure sustainable life and desirable futures. Open schooling facilitates support from families and scientists so that students can solve real-life problems.

- Outreach practices: with the organization of open-to-community events or the use of social media and several means for campaigns, students can provide the community with information and late updates on their initiatives

Challenges & Barriers

Examples of challenges that teachers possibly encounter when teaching climate change are the following:

- Students' and their families' alternative ideas: "Several beliefs, such as the idea that climate change is gradually evolving, can encourage behaviors such as 'wait-and-see,' leading some to believe that individual action is not necessary or not enough to mitigate the drivers of climate change."

- Limited time and resources: In many educational settings, there may be limited time available to cover climate change in depth, which can result in superficial or incomplete coverage of the topic. In addition, teachers often avoid using methods such as project-based learning since

they are time-consuming. In addition, they need further education in order to explore and implement updated resources.

- Difficulties in implementing interdisciplinary approaches: Teachers often face difficulties in implementing interdisciplinary approaches since is difficult for them to know the cross-cutting concepts while implementing them in a way that makes prominent the interconnection of the various disciplines.

There are many best practices or strategies that teachers can use to address challenges and barriers in teaching climate change. Some examples of those practices and strategies are to provide opportunities to participate in professional development programs in order to be able to address effectively those barriers, to build teachers' content knowledge on climate change and make aware them of how to engage students in participatory activities. In order to increase students' engagement, they can use interactive digital tools and resources as well as hands-on activities, field trips, project-based learning, and partnering with stakeholders from the local community. In addition, encouraging students to participate in volunteer initiatives concerning the community can help them be aware of the importance of action-taking regarding climate change.

In Portugal

Teacher Training

All participants agreed that is fundamental to better equip teachers and educators for climate change education. Climate change is not much approached in traditional classes such as science and biology, it relies mostly on being approached in optional and transdisciplinary classes. These classes may or may not be given by a teacher from sciences and so, is necessary to equip teachers from all lecturing fields about the subject, to do so nationally implemented resources must be developed. These resources need to be widely available, easy to understand, and interactive to engage both teachers and students.

Overall, the discussion always leads to the lack of educational resources in Portuguese.

Collaboration and Partnership

Typically, the involvement of different stakeholders in climate change education initiatives is sparse and scattered. The involvement of other type of participant besides the teacher, for most, is limited to other schools staff.

Some governmental initiatives have been successful in ensuring partnerships over school walls like the "Ciência Viva" programs that maintain partnerships with local agricultural facilities. Other iniciatives are made on a local level, where teachers and school coordinators establish protocols with municipalities, parks and other facilities that are linked to sustainable practices.

Overall, climate change education is practiced within school grounds and the community is not very involved. The partnerships established depends mostly on teachers initiatives and school interests.

Challenges & Barriers

The main barriers presented were, to start, the lack of educational resources to use. Secondly the demotivation of some students, especially those from more rural areas and in difficult socioeconomic conditions. Students with some socioeconomic disadvantages are usually harder to reach and engage since they are, understandably, more focused on means of subsistence and material goods.

In terms of grasping climate change, many students see it as an abstract concept and are so used to living with the effects of climate change that there's a level of difficulty in identifying its effects. Furthermore, some students when they are able to identify some consequences of climate change, such as changes in season, there is a sense of acceptance and normalization of the matter. There is a general feeling of difficulty in translating climate change as a concept to climate change as a real-life event. In parallel, other students display anxiety when confronted with the consequences of climate change, like the effects of acid rains. The younger generations are displaying symptoms of anxiety and depression earlier than the previous generations and so, teaching them about sensitive topics is a difficult balance between informing and causing negative feeling that can lead to climatic stress, for instance.

Participants also agreed that since covid, general population and consequently children, there is a sense of disbelieve in science that can put in peril education.

Envisioning the Future for Climate Change Education

General Findings

Some potential improvements include: In order to improve climate change and environmental education, the focus groups findings point out that on general terms teacher required more training and support. The support needed also includes the resources that need to be:

1. **Be updated and accurate information** - As the science of climate change evolves and new information becomes available, it is important for educational resources to be updated and reflect the most current research and understanding of climate change.

2. **Focus on real-world impacts** - Students are more likely to engage with and be motivated to learn about climate change if they can see its real-world impacts. Educational resources should emphasize the immediate and long-term effects of climate change on local communities, economies, and ecosystems.

3. **Greater use of interactive and multimedia resources** - To keep students engaged, educational resources could be designed to include more interactive and multimedia resources such as videos, simulations, and games.

4. **Incorporation of cross-curricular activities** - Climate change is a multidisciplinary issue, and it can be beneficial to include activities that span across multiple subjects, such as science, math, social studies, and language arts.

5. **Focus on solutions** - It is important to not only educate students about the problem of climate change but also empower them with the knowledge and skills to become agents of change. The educational resources and curriculum could be designed to focus on solutions, including local and global initiatives to mitigate and adapt to climate change.

Overall, improvements to the resources and curriculum for climate change education should focus on making the material engaging, relevant, and actionable for students. By achieving this, the teachers workload will also decrease which allows them to dedicate more time to explore and implement this innovative approaches to teach climate change and environmental topics.

Furthermore, it is recommended closer cooperation and collaboration between universities and schools, to achieve an effective teaching experience concerning both the scientific content and the teaching methodologies. A bigger emphasis on real-world problems and phenomena should also be given since those problems engage students in questioning, experiential learning, and hands-on activities that promote active learning and motivational learning, are ill-structured with multiple solutions and familiarize students with the complexity of the real world.

The digitalization of the educational sector is also a priority and, as observed since the pandemic, a necessity. Environmental and climate change education should also follow this trend since the wider use of digital technologies as they increase engagement and motivation, are interactive and help students to build digital competencies.

Since climate change is a topic that requires not only skills and knowledge from multiple disciplines but also a deeper integration between those disciplines promoting a holistic approach and systemic thinking. A interdisciplinary/transdisciplinary approach to climate change is vital to achieve the desired learning outcomes.

National Findings

In Cyprus

According to our focus group participants, Climate Change Education in Cyprus sought to aim to bridge the existing systemic, organisational, administrative and educational gaps and limitations exhibited by the local educational landscape. The gradual exacerbation of climate change

implications, in their view, might call for educational approaches which do not merely encourage preventive measures but instead touch upon Mitigation and Adaptation Strategies to what might be possibly irreversible. Conclusively, adaptation strategies might as well constitute henceforward a key educational content element aiming to support students coping with the impacts of climate change (e.g. preparing for extreme weather events, building resilient infrastructure, implementing water management plans etc.)

In Greece

Considering the different needs in every Greek region (weather, educational capacity, number of students and teachers etc.) and the different circumstances in every school, the main focus should be the creation of different programs, policies and provisions when it comes to climate change education. For example, climate change education should be different for schools in villages and different for schools that are situated in a big city. According to participants, another main focus should become the energy autonomy of each school. Schools should be able to produce their own electricity, heating etc. in cases of extreme weather phenomena and remote regions, as it frequently happens in Greece the last few years. This can be achieved through the participation of schools to ESPA programs funded by the EU.

Lastly, the most important thing is to focus on raising students' awareness and making them understand that climate change is an issue of survival that concerns them all. Students should comprehend that the fight against climate change is a collective effort and they need to be a part of it.

In Ireland

In the future, the main focus of climate change education in schools should be to prepare students to understand and address the current and future impacts of climate change. This includes developing an understanding of the scientific principles underlying climate change, as well as the social, economic, and political implications of climate change. Additionally, education should focus on empowering students to become agents of change and to take positive actions to mitigate and adapt to the impacts of climate change. This may include promoting sustainable behaviours, advocating for policy change, and developing new technologies and solutions that can help to address the challenges of climate change. Ultimately, the goal should be to create a generation of environmentally literate citizens who are equipped to make informed decisions and take meaningful actions to address the complex and pressing challenges of climate change.

In the Netherlands

Climate change education should focus in the future on students' deeper understanding of the scientific, social, ethical, and cultural complexities of climate change, as well as on building their ability to think holistically, critically and creatively. An interdisciplinary or transdisciplinary approach can have a significant offer to this new way of thinking with the contribution of multiple disciplines' perspectives, knowledge and methods. Students should be prepared for future climate change projections, the development and interpretation of climate models, and the issues of uncertainty inherent in climate science. Additionally, they should be open to a radical and visionary alternative of a more sustainable future within planetary boundaries and become agents of change. Future climate change education should increase students' awareness of the social and ethical aspects of climate change impacts, such as issues of social justice, equity, and human rights that emerge in most vulnerable populations. Finally, the role of climate change education will be critical in students' climate literacy and promotion of decision-making and action-taking.

In the following paragraphs are presented examples of innovative methods that contribute to achieving the aforementioned objectives. Some of those methods are:

- Project-based learning: In the PjBL approach, students work collaboratively on a problem or issue strongly related to real-world problems concerning climate change. This approach can be particularly effective in developing students' skills in teamwork, problem-solving, and critical thinking.

- Gamification: Through serious games students can be engaged in real-world activities, providing them with motivation for scaffolding climate change-oriented actions in everyday life. Gamification can take many forms, from digital games and simulations to physical games and activities.

- Socioscientific issues: In SSI, students are presented with real-world situations related to climate change, such as the use of renewable energy sources, land-use changes, and climate change adaptation measures, to engage them in dialogue, discussion, and debate. SSI teaching and learning approach can promote the general aim of climate literacy.

- Place-based education: Place-based education uses local environments as starting points to teach climate change since it emphasizes hands-on, real-world learning experiences to develop emotional bonds with communities. This process is designed to enhance appreciation for the natural environment and stimulate citizenship.

- Storyline approach: a storyline is a physically self-consistent unfolding of past events, or plausible future events or pathways that are used in understanding the driving factors

involved and the plausibility of those factors. In this approach, students are engaged in the negotiation of past events and plausible future events based on evidence and taking into consideration the uncertainty that concerns the climate phenomena.

- Phenomena-based learning: Phenomena-based learning is based on problem-based learning while promoting systemic and holistic thinking in the context of wicked problems. In order to resolve climate change, thinking from the perspective of different disciplines is more effective than a monodisciplinary point of view.

- Arts-based learning: This approach refers to the purposeful use of artistic skills, processes, and experiences as educational tools to foster learning about climate change issues. Arts can offer space and provide means for the critical issues of climate change education through emotional involvement, personal meaning-making, critical thinking, active agency and creative visioning.

In Portugal

In terms of traditional learning, all participants agreed that it was necessary to have strong theoretical material about climate change. Language should be simple to reach all students from every background and interest. The issues of climate change should be presented in a truthful manner whilst considering the climatic stress that might bring to the young pupils. With every consequence associated with climate change, a solution must be presented. Altogether, a collection of best practices to fight climate change should be developed to create a sense of awareness, and hope and promote advocacy.

 Furthermore, participants highlight the need to teach climate change as a fluid science, constantly evolving as we learn more about it and have more data. To achieve this, notions on how scientific predictions or models work should be provided, this aims to avoid distrust and disbelief in science in case future scenarios change. Climate change should be approached as a concrete event, with real-life causes and consequences.

Furthermore, participants believe reasoning that "we need to fight climate change to protect our planet" is insufficient to raise awareness and is very limiting to the problem. They suggested the introduction of a socio-humanistic component, where students became sensitized by the impacts that climate change has on society and on those more fustigated by it, usually from developing countries. This approach envisions creating understanding and empathy for others and in this way, promotes behavioural changes toward sustainability. Participants also showed interest in gamified resources as a way to keep pupils engaged in the learning process.

To summarize, even without using the terminology STEAM education, participants salient the importance of an interdisciplinary approach to learning and the need to develop soft skills in students.

Conclusion

Summary of key takeaways from the e-Guide

The complexity of climate change and the climate emergency the world is currently facing turns pivotal climate change and environmental education on the school settings. Even though teachers on a all have a good grasp on what is climate change, this complexity makes the subject quite difficult to teach. Young students often have difficulties in grasping climate change and turning it into more than a concept.

Despite its importance, the incorporation of these topics on national educational programmes is still in its begging, has is the implementation of STEAM education. Often programmes lack a clear framing and proper training of teachers. Furthermore, the recent covid-19 pandemic, had an undeniable deep effect on the educational system and teachers. It required immediate adaption of the curriculum and caused an overload of work in the educational experts.

On a brighter side, the importance of climate change and STEAM education in schools, to proper equip the next generation, are unanimously accepted.

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ANNEX A

Additional educational curriculums and resources for Cyprus

Supportive additional material for teachers on Super User (2020) can be consulted on:

1. For primary education: https://peeaad.schools.ac.cy/index.php/el/yliko/endeiktiko-yliko

2. For teaching about waste: https://peeaad.schools.ac.cy/index.php/el/yliko/aporrimata

3. For teaching about Urban Development:

   https://peeaad.schools.ac.cy/index.php/el/yliko/astiki-anaptyxi

4. For teaching about Biodiversity:

   https://peeaad.schools.ac.cy/index.php/el/yliko/viopoikilotita

5. For teaching about the Forest: https://peeaad.schools.ac.cy/index.php/el/yliko/dasos

6. For teaching about Energy: https://peeaad.schools.ac.cy/index.php/el/yliko/energeia

7. For teaching about Transport systems:

   https://peeaad.schools.ac.cy/index.php/el/yliko/mesa-metaforas

8. For teaching about Water: https://peeaad.schools.ac.cy/index.php/el/yliko/nero

9. For teaching about Production and consumption:

    https://peeaad.schools.ac.cy/index.php/el/yliko/paragogi-katanalosi

10. For teaching about Culture and Environment:

    https://peeaad.schools.ac.cy/index.php/el/yliko/politismos-perivallon

11. For teaching about Green Tourism:

    https://peeaad.schools.ac.cy/index.php/el/yliko/tourismos

12. For teaching about Climate Change Induced Poverty:

    https://peeaad.schools.ac.cy/index.php/el/yliko/ftochia