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Deliverable 6.5 - Design and evaluation of school-based citizen science activities

Interim report

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DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press & media actions, videos, photos, etc.	
SOF	Software, technical diagram, etc.	
OTHER	Flyers, etc.	

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Executive Summary

This is the interim report of **Deliverable 6.5 "Design and Evaluation of School-based Citizen Science Activities"**, the final version of which is formally due on **M36**. D6.5 reports on work conducted within Work Package 6 (**WP6**) and more specifically under Sub-Task **6.4.2** (**Set-up and evaluation of innovative school-based citizen-science activities**). The **NKUA** team who is responsible for authoring and submitting D6.5 is also the leading partner in Sub-Task 6.4.2.

D6.5 reports on the work being carried out under Sub-Task 6.4.2. This work involves **a set of interrelated and mutually contributing actions** that have been conceived to form the strategy (**general design model**) for facilitating, supporting, implementing and evaluating school-based citizen science activities and projects that make use of the Cos4Cloud CO platforms. These actions, which are aligned to the Cos4Cloud project's goals to support **the widening of current citizen science practice** through the **engagement of new target audiences**, **school population** in particular, build on the following:

- the design, organization and implementation of **an online training course** for Greek teachers and key educational stakeholders involved in or coordinating the school practice of Environmental Education/ Education for Sustainability (EE/ESD)
- the creation of **an educational network** of primary and secondary schools/ teachers/ educational stakeholders, not only eager to participate in co-design activities for the Cos4Cloud technologies and new services, but also willing and competent to support the integration of citizen science into the regular school practice and the engagement of school students and communities
- the development of a set of **educational scenarios**, i.e. educational designs for implementing citizen science activities and projects in schools that make use of selected Cos4Cloud CO platforms
- the coordination and implementation of a range of **case studies of educational activities and projects** in primary and secondary schools with the collaboration of school teachers and other educational stakeholders,
- the **evaluation** of the school case studies in terms of their learning potential and educational impact in cultivating an environmentally and scientifically literate and active citizenry based on the analysis of qualitative data
- the compilation of the evaluation findings into a **meaningful evidence-based input** for European and national policy-makers about a new citizen science paradigm aligned to the EOSC idea and implementation.

In the current **interim** version of **D6.5** we report on the work carried out **from M4 to M26** we regards to the design, coordination and implementation of the actions mentioned above.

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1. INTRODUCTION

1.1. Outline of Sub-Task 6.4.2 and Deliverable 6.5

This is the intermediate version of **Deliverable 6.5 "Design and Evaluation of School-based Citizen Science Activities"**, the final version of which is formally due on **M36**. D6.5 reports on work conducted within Work Package 6 (**WP6**) and more specifically under Sub-Task **6.4.2** (**Set-up and evaluation of innovative school-based citizen-science activities**). The **NKUA** who is responsible for authoring and submitting D6.5 is also the leading partner in Sub-Task 6.4.2.

WP6 (Networking, Training and Capacity Building) aims (a) to ensure that the Cos4Cloud project's model addresses and fulfils the needs of different target populations and stakeholders; and (b) to facilitate, support and document engagement with and for the project's citizen observatories based on the co-design and implementation of new tools, services and initiatives that advance networking, knowledge exchange, capacity building, training, and education. The ambition is that all these new tools and initiatives become components of an integrated approach to citizen science across the network of the Cos4Cloud project's citizen observatories that scales up across Europe. Moreover, insights and evidence-based input to be developed from the implementation of these actions will be highlighted as best practice and proposed as useful background knowledge for European and national policy-makerswithin the EOSC Hub and across Europe.

Overall work under **WP6** (coordinated by the OU) is carried out through a range of integrated tasks and subtasks, with mainly OU, CSIC and the NKUA leading on their delivery and/or contributing to them. The current report (D6.5 "Design and Evaluation of School-based Citizen Science Activities") informs about work conducted under 6.4.2, which is a subtask of **Task 6.4** (**Evaluation of citizen engagement, educational learning methodologies and citizen-science impact**). Task 6.4 aims to build a framework for monitoring and evaluating citizens and stakeholders' engagement in activities, the impact on citizens and communities engaged in such activities, as well as learning through citizen science, in both formal and informal contexts. Within Task 6.4 citizens' engagement methodologies will be proposed and evaluated with regards to their impact on the community. New partnerships, with school communities in particular, will be set up and evaluated as to their learning potential, by making use of both quantitative metrics but mostly soft evaluation data to assess the effectiveness of the adopted engagement strategies in enhancing citizen participation. The outputs from the evaluation will inform the final model for long term, large-scale engagement in citizen science by the Cos4Cloud project as part of the EOSC Hub.

Sub Task 6.4.2 (**Set-up and evaluation of innovative school-based citizen-science activities**) is led by and delivered by NKUA with contributions from OU, CSIC, and other partners). It is premised on the idea that citizen science creates a nexus between science, public participation and education, which, when coupled with digital technologies, can widen the opportunities for and impact on research, the citizens' active involvement and learning to open science and education. In particular, we claim that environmental community-based citizen

science monitoring which makes use of the citizen observatories technologies, tools and services as integrated to the EOSC Hub based on the proposed Cos4Cloud project's model, can facilitate and contribute to scientific knowledge transfer from citizen science organisations and stakeholders to European school populations, and vice versa. It can also support innovative and integrative teaching and learning approaches and outcomes in the school communities and other formal education contexts towards sustainability.

Work as outlined in the project's Grant Agreement to be conducted under **Sub Task 6.4.2** is specified in relation to a range of actions to be led and coordinated by the NKUA, including: "*to set up a network of (a) primary and secondary schools and (b) teachers and other educational stakeholders, on a European level, to test the COS4CLOUD project's objectives and services and how they can support the widening of current citizen science practice and the democratisation of procedures through the engagement of new target audiences, school population in particular. A range of school-based CS designs making use of the CO platforms will be implemented and evaluated with the collaboration of local partners. Training seminars will be organised, educational material will be developed and online support will be provided to all those involved in the implementation of the activities (students, teachers and other educational stakeholders). Finally, all activities will be evaluated to provide evidence-based input to European and national policy-makers about their learning potential and educational impact in cultivating an environmentally and scientifically literate and active citizenry. To this end, evaluation will be based on the collection and analysis of qualitative data and the in-depth examination of specific case-studies so that rich and meaningful evidence is available to inform a new citizen science paradigm better aligned to the EOSC idea and implementation*." (p. 37).

Following the rationale and specifications for **Sub Task 6.4.2** and in line with the general objectives and ambitions as set out for WP6, Task 6.4 in particular, the NKUA proceeded with the development of a **general design model** and an **implementation approach**, which are reported under **D6.5 (Design and evaluation of school-based citizen science activities)** ("*This report will present the general design model and the implementation approach of the school based CS activities*", Project's Grant Agreement, p. 38). In more detail, the NKUA developed a strategy (general design model) for and an approach to facilitate, support, implement and evaluate school-based citizen science activities that make use of individual citizen observatories participating in the Cos4Cloud project. This strategy and approach comprise a range of **integrated actions**, which are aligned to the Cos4Cloud project's goals to widen current citizen science practice to European school communities and foster the students' learning and general educational impact of citizen science in line with the Cos4Cloud project's model. These actions, which were conceived as **interrelated and mutually contributing,** build on the following:

- the design, organization and implementation of **an online training course** for Greek teachers and key educational stakeholders who are directly involved in supporting the school practice of Environmental Education/ Education for Sustainability (EE/ESD);
- the creation of **an educational network** of primary and secondary schools/ teachers/ educational stakeholders, who will not be only eager to participate in co-design activities for testing the Cos4Cloud technologies and new services, but also willing to support the

integration of citizen science activities into regular school practice and the engagement of school students and communities;

- the development of a set of **educational scenarios**, i.e., educational designs for implementing citizen science activities and projects in schools, which make use of the technologies and tools of selected citizen observatories (CO) participating in the Cos4Cloud project;
- the coordination and implementation of a range of **case studies of educational projects and activities** in primary and secondary schools with the collaboration of school teachers and other educational stakeholders;
- the **evaluation** of the school case studies in terms of their **learning potential** and **educational impact** in cultivating an environmentally and scientifically literate and active citizenry based on the analysis of **qualitative data**;
- the compilation of the evaluation findings into a **meaningful evidence-based input** for European and national policy-makers and in order to a new citizen science paradigm better aligned to the EOSC idea and implementation.

The main work in relation to all the above mentioned actions in Sub Task 6.4.2 is led and carried out by the NKUA with the contribution and cooperation of OU, CSIC, INRIA, Science for Change, CanAir.io and all partners.

1.2. Citizen science and education as two parameters of open science

In the Recommendation on the Open Science signed by the UNESCO on the 23 November 2021, the United Nations Assembly recognizes the urgency of addressing complex and interconnected socio-environmental challenges, including loss of biodiversity, climate change, natural resource depletion and land degradation. It also acknowledges that science, technology and innovation (STI) can respond to these challenges by providing solutions to improve human well-being and environmental sustainability. **Open Science** defined as *an array of favourable conditions, infrastructures and practices aiming to make scientific knowledge publicly available, accessible and reusable for all people; to reinforce the sharing of information for the benefit of both science and society; and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community*, offers considerable potential for building progress towards the achievement of the Sustainable Development Goals (SDGs) and more resilient communities and economies.

Open science can be enabled in many fields and enhanced through many ways. Two of them, **citizen science** and **education**, are integral to the very idea of open science and contribute to its practice. **Citizen science** shares a lot of common ideas and principles with open science. As adequately stated by Smallman (2018), citizen science is both an aim and an enabler of open science. Open science's approaches are at the roots of current citizen science's practices while they inspire many of its ongoing and future concerns and developments (ECSA Working Group on citizen science and open science). Likewise, citizen science is considered an important aspect in the conceptualisation of open science in terms of how research opens up to more contributors along the sequence of stages and procedures, and how science relates to wider

societal goals. As stated by Hecker, Haklay, Bowser, Makush and Vogel (2018), citizen science contributes to open science by engaging citizens in research and opening the process of creating new knowledge through participation. In turn, this leads to greater understanding of science by open information and communication and can stimulate active participation in policy-making. It is obvious that citizen science is not only in line with the principles of open science, but can be greatly enhanced by open science's practices. Therefore, citizen science organisations and practitioners should be encouraged to adhere to open science principles and practices. This is why EU policy (European Commission, 2016) that strongly supports open science practices highlights citizen science as one of the 8 central ambitions in the EU's Agenda for Open Science (European Commission, 2019).

Opening scientific research procedures and sharing scientific knowledge to the wider public are just two parameters of open science which are closely linked to **education**. Education and training are important steps to establish awareness and familiarization with open science practices not only among traditional and amateur (citizen) scientists but also for students across all educational levels (Schönbrodt, 2019). The same applies to the availability of appropriate teaching and learning materials (i.e., handbooks and online educational resources), to expand open science skills not only among researchers but also beyond them to various educational stakeholders (Mendez et al., 2020). Open science can also contribute to and enhance many aspects of teaching and learning, such as by promoting open education processes, making both data and publications openly accessible (Ross-Hellauer, 2017), or through open educational resources (Anderson, 2013). Many educational policy-makers as well as lecturers and teachers have already endorsed open education and open science processes in their regular courses, including open content, open teaching and learning and open educational resources (Mendez, et al., 2020). Moreover, there is growing evidence of efforts to integrate open science into educational scenarios for students in higher education (Garde-Hansen & Calvert, 2016), although practices such as these are still very limited (Bossu & Heck, 2020) and certainly not so much applied to school education audiences.

1.3. Citizen science and education: affinities, opportunities and challenges

Citizen science and education are highlighted by the European Commission's "Science with and for Society" work programme (European Commission, 2017) as areas that share many affinities and interconnections and which need to be further explored along with open science and public engagement to the benefit of European societies. In particular, **education meets citizen science at many points of intersection**. Education is among the public policy issues, along with environmental protection, health and innovation that are promoted by many citizen science projects. It is also one of the sectors that benefit the most from the knowledge generated by citizen science. Moreover, education is highlighted as an important mechanism to be used to ensure that citizen science receives publicity in a wider context and expands beyond the individual volunteers already motivated and existing projects (Roche et al., 2020).

On the other hand, **citizen science serves various educational goals** in addition to purely scientific purposes (Kieslinger et al., 2018). All those involved in some kind of citizen science activity contribute to important scientific processes, such as the collection and analysis of information, while also engaging in some kind of learning process that has to do not only with the acquisition of the content knowledge and skills necessary for citizen science per se, but also with the development of scientific literacy. This is related to a deeper understanding of scientific concepts and processes (Brossard et al., 2005; Jordan et al., 2011; Saunders et al., 2018), which is why citizen science is very often linked to science education and science learning (European Commission 2016; Bonney et al., 2016).

However, there are many more **learning outcomes and educational impacts for those involved in citizen science projects and initiatives** (Roche et al., 2020), related to different types of literacies and competencies, which renders the integration of citizen science in education a central point of interest for educational research and evaluation. Among other scholars, Edwards et al. (2018) argue that the benefits of participating in citizen science go beyond improving scientific and topical knowledge and developing knowledge about scientific inquiry to include the development of a range of competencies and skills, such as critical thinking and environmental citizenship Children's participation in citizen science activities appears to be positively correlated with improved understanding of science and/or commitment safeguarding nature and the environment (Makuch & Aczel, 2018). Fostering stewardship and empowerment as much as science literacy adds a more societal perspective to the learning potential and educational impact of citizen science to raise a range of 'literacies' and 'competences' in the context of engaging people with science-related activities and science-related outcomes, including learning (Edwards et al., 2018).

All the aforementioned provide substantial evidence for **the need to further explore and strengthen the synergies between citizen science and formal education and learning** (Roche et al., 2020). *How can citizen science as a concept and practice be integrated into the curricula of formal educational institutions such as schools, colleges and universities? How can such integration overcome various barriers and constraints and create learning spaces for a fruitful and mutually beneficial relationship? How can students be motivated to participate in school-based citizen science activities and how can their engagement be sustained as a continuation of that participation? What is the learning potential and broader educational impact generated from different models of integrating and implementing citizen science in formal education procedures and settings? Can citizen science enhance learning at different ages and educational stages? And, how should the opportunities offered through primary, secondary and higher education as well as through teacher training be used to reinforce the citizens' knowledge and participation in science?*

These are some of the questions raised, which argue for the need for more experimentation and better evaluation of different models of integrating citizen science in different educational contexts and situations. The **role of teachers and other educational stakeholders**, as key mediators between citizen science and school practice (Weinstein, 2012) also needs to be addressed and supported through **networking**, the development of appropriate **background materials and educational and training resources**, and the sharing of **successful stories**

and methodologies (Bonney et al., 2009; Bonney et al., 2014). In the Cos4Cloud project we argue that the outcomes of such efforts will help address the challenges and strengthen the opportunities to integrate citizen science into formal education (Harlin et al., 2018) for the benefit of the students' learning, the empowerment of the school communities, and the advancement of scientific research and the sustainability of local environments.

1.4. Developing synergies between environmental education, science education and citizen science

Current environmental issues, such as climate change, biodiversity loss and environmental pollution, are placing a significant burden on life and quality of life on a global scale, by affecting human and ecosystem health and activity and by undermining the function and cohesion of local communities. As a response to this urgent call, **education** draws on existing practices, develops synergies and search for new opportunities to engage people with learning about and for dealing with these issues commonly referred to as '**sustainability challenges**'.

Environmental Education (EE) and **Science Education** (SE) are two educational areas that both seek to construct and facilitate people's engagement in learning about these issues, albeit each from a different perspective. SE focuses primarily on teaching fundamental scientific concepts and content knowledge and skills that enable people to observe and understand phenomena (Wals et al., 2014). On the other hand EE, without downgrading the acquisition of scientific knowledge and skills, emphasizes the cultivation of values and competences that feed processes of individual and collective inquiry and the active and critical construction of knowledge as prerequisites to democratic participation for more sustainable futures (Jensen & Schnack, 1997; Breiting & Mogensen, 1999). Thus, for example, SE may focus on teaching fundamental scientific concepts and skills in relation to, e.g., how to measure water quality and understand the technologies that can reduce pollution, while EE is primarily interested in helping students to identify and analyze the overall conditions and human practices in particular that cause water pollution in general or are behind a particular such incident or outbreak, and to seek alternative ways to address the problem in cooperation with the local community, policy-makers and other stakeholders (Wals et al., ibid).

As for **citizen science**, much of its current practice focuses on engaging people in science and action on specific environmental issues and topics, in collaboration with scientists and local stakeholders (Bonney et al., 2014; Dickinson et al., 2012). Environmental citizen science involves and promotes community-based monitoring of the local environment with the use of customized digital devices and technologies for data collection and sharing. In doing so, it aims to increase scientific and environmental literacy and develop global citizenship through the active participation of citizens in local issues. Education and learning may not be among its first and explicit goals; however, there is an inherent link between participation in environmental citizen science projects and environmental learning.

Although citizen science is differentiated from EE, there is alignment in the way both see their role, namely **emphasizing active participation in individual and collective processes of inquiry on current environmental and sustainability issues**. The involvement of people in

actions related to local environmental and sustainability issues seems to be common in the ambitions and practices of the EE, SE and citizen science. The concept of an environmentally active and responsible citizen is a central tenet for both citizen science and EE and a key tool for promoting sustainability. Environmental awareness and participation in policy-making are also expected outcomes together with the development of a sense of place. However, as noted by Wals et al. (2014), despite the fact that there are so many common grounds, there have not yet been significant efforts to bring them together. They also argue that **creating synergies between citizen science, SE and EE** can be of benefit to science, local communities and educational processes and can certainly enhance social sustainability efforts.

Responsible and active citizen engagement and informed participation to achieve sustainability are at the core of citizen science (Hecker et al., 2018; Tauginienė et al., 2020). On the other hand, EE departs from engaging with science in the traditional way and opens up new ways to learning emphasizing experience, intrinsic motivation, self-directed engagement and collaboration in an effort to explore and address local sustainability issues and concerns (UNESCO, 2020). To this end, a pedagogy that includes challenge-based, interdisciplinary and action-oriented learning and participation in authentic learning situations that can take place in formal and informal education contexts (UNESCO, 2019) is promoted to empower young people to become active and responsible citizens (UNESCO, 2017).

To this end, Wals et al. (2014) propose the creation of synergies between EE, SE and citizen science using digital technologies and tools. These synergies would act as **a mechanism to enhance public engagement and socio-ecological learning on current environmental and sustainability issues**. They would also promote new opportunities and forms of learning based on the collaborative production of knowledge and towards empowering people, especially youths, to address current environmental problems and sustainability challenges with a broader perspective.

Another point also discussed by Wals et al. (2014) that could further enrich the synergies between EE, SE and citizen science, comes from recent developments in EE research and evaluation on learning. As they point out, the focus is not so much on measuring specific learning outcomes in terms of content knowledge and skills acquired, but rather on the learning processes involved and the general competences developed in relation to the issues engaged with. The emphasis is on **learning potential** and the overall **educational impact** on students, the school and the local community. This requires a better understanding of students' and teachers' cognitive and emotional responses to the environmental issues and challenges and a focus on how their belief systems are associated with their personal and place identity (Stevenson & Sterling, 2010).

1.5. The Cos4Cloud project's proposed model of integrating citizen science in school-based education

In the Cos4Cloud project we argue that citizen science, SE and EE are not only congruent and complementary to each other, but there is **great potential to integrate them into school educational practice**. We believe that such integration launches **an emerging 'paradigm' of**

educational practice that opens up diverse opportunities towards learning and empowerment for sustainability. We also suggest that we contribute to this goal by adopting a broader perspective on integrating citizen science into school EE practice and promoting the collaboration between researchers, citizen scientists, science educators and environmental educators.

We therefore designed and implemented **a model of integration** that builds on a symbiotic relationship between citizen science, SE and EE, making use of the technologies, tools and services of the Cos4Cloud citizen observatories. This model (see Fig. 1) promotes the **co-design and co-creation of learning situations** and supports their implementation through different **mechanisms**. In short, the model has been designed along the following three interrelated axes:

(a) the creation of an **educational network** of school teachers, educators, educational stakeholders and schools that are willing and able to support the integration of citizen science through school EE projects and activities,

(b) the provision of **teacher training programs** and **resources** to assist teachers in integrating citizen science into their EE teaching practices; and

(c) the design and implementation of a range of **educational projects and activities in schools** and the **evaluation** of their learning potential and educational impact.

Furthermore, all actions arising from this model aim to empower learners, practitioners and other educational stakeholders to think critically and creatively when organizing, conducting, participating, learning and evaluating their engagement with environmental issues in their local environments as part of an active citizenship towards sustainability.

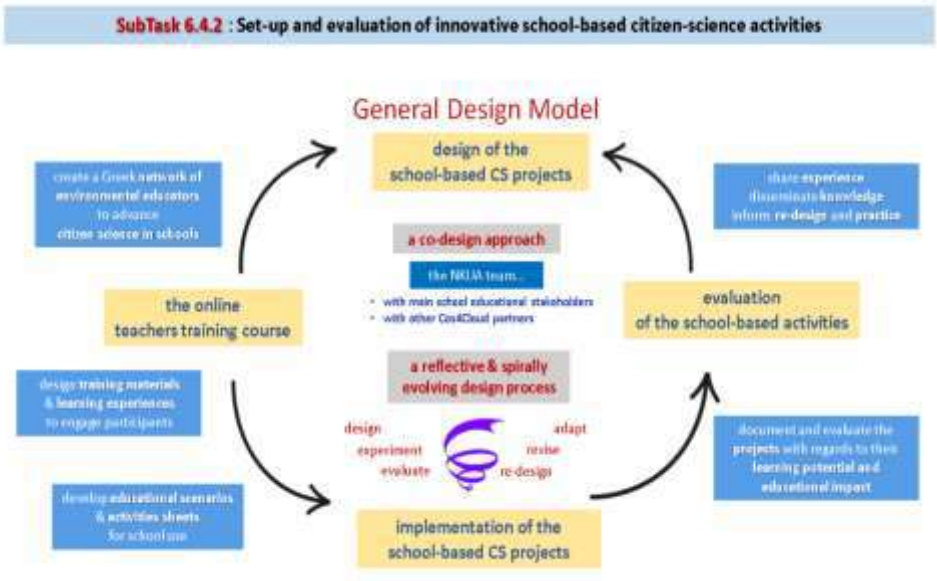

Figure 1: The General Design Model of integrating citizen science in school education

2. THE ONLINE TRAINING COURSE

2.1. Introduction

One of the first actions led by the National and Kapodistrian University of Athens (NKUA) under SubTask 6.4.2 was the design and implementation of the online training course "**Environmental Education for Sustainability and Citizen Science**". This training program was designated as a strategic action to pave the way for the initiatives and actions to follow (see Fig. 2). It therefore held a pivotal position in the Cos4Cloud project's **general design model** and **approach to set-up school-based citizen science projects and activities,** as laid out in SubTask 6.4.2 and described in **D6.5** ("Design and evaluation of school-based CS activities").

The course was designed to pursue several interconnected goals, starting from (**a**) the selection of a core group of Greek teachers and school education stakeholders from the areas of Environmental Education and Education for Sustainable Development (EE/ESD) as the target audience to be trained to get involved in (**b**) the **design, implementation and evaluation** of school-based citizen science educational projects **and activities** that would make use of the Cos4Cloud project's Citizen Observatories (CO) technologies.

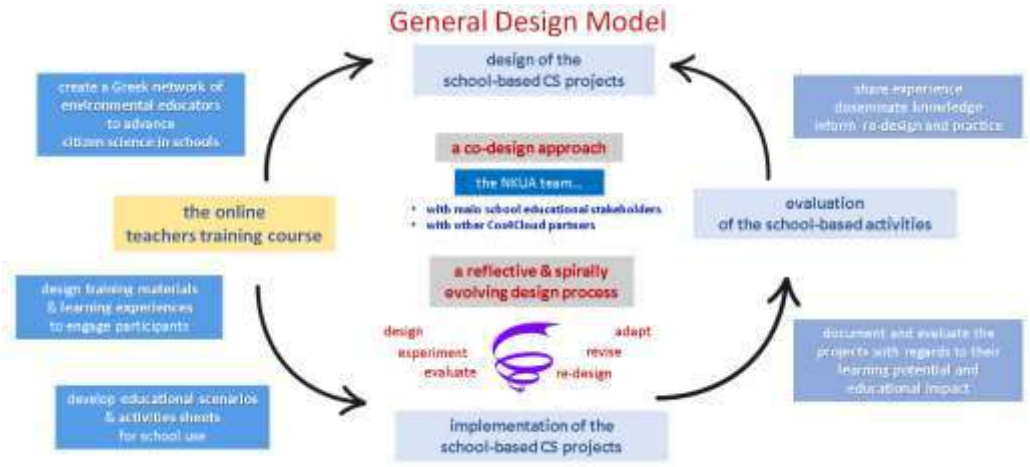

Figure 2: The strategic position of the online teacher training course in the General Design Model

Participants in the course were to (**c**) form a **community of learning and practice** and become the first educational network to integrate citizen science practice in Greek schools based on (**d**) the co-design of a set of related open educational resources (**educational materials and learning scenarios** for school use), that would serve as guiding frameworks for introducing citizen science and the project's technologies into their personal teaching practice as well inspire and support other teachers' practice too. The teacher training course was conducted online with the use of (**e**) appropriate open **training materials and learning experiences**

formats that were purposively designed by the NKUA team to be both informative and engaging as well as open to adaptation and reuse in the context of new or similar training courses.

The rationale and methodology for the design and implementation of the online training course were shaped through a reflective and spirally evolving process following **a co-design approach**: the NKUA collaborated with other Cos4Cloud partners to determine the main aspects of the course. Co-design was a core element of many processes and outcomes inherent to the course: i.e., the NKUA team collaborated with the course's participants to design, try out, evaluate, adapt, revise and/or re-design their educational scenarios as well as the implementation and evaluation of their school projects. To this end, the NKUA elaborated and used a set of 'templates' to scaffold communication, exchange and collaboration with the trainees and to foster creativity and reflection in educational design and evaluation. In the following sections we give an outline of the main elements and phases of the online course and the methodology underpinning its design and implementation.

2.2. The online training course in brief

The **100-hour** online training course took place from **July to December 2020**. It was designed, organised and run by the **Environmental Education Lab** of the NKUA with the technical support of the NKUA's **Centre for Continuous Education** (CCE). It was hosted on the CCE's Open eClass platform (https://eclass.cce.uoa.gr/courses/CCEHUMAN121/). Twenty-three (23) participants were invited to enrol, of whom 22 completed the course successfully and received a Training Certificate and a Europass Certificate Supplement (total ECVET points: 4).

The course's main objectives were:

(a) to introduce key agents of the EE/ESD school practice (teachers and other educational stakeholders) to the emerging field of citizen science, the role and status of citizen observatories (CO), and the aims of the Cos4Cloud project, as well as to explore the affinities between citizen science and EE/ESD.

(b) to train them in the collaborative design of educational projects and activities, that are conducive to the aims of the Cos4Cloud project, but also go beyond that, in offering an innovative pedagogy with multiple learning benefits for the students, in terms of their scientific and environmental literacy and the development of their citizenship.

2.3. Design, organization and development of the online training course

The decisions and steps taken before the implementation of the training course were essential for its successful organization and delivery. The **initial idea and proposed rationale** of an online training course for teachers and educational stakeholders belongs to the NKUA, who discussed it with the project's coordinators (CSIC), the WP6 leader (OU) and other project partners (e.g., INRIA, ECSA, Trébola, Science for Change) in two online meetings and more email exchanges. All parties approved the idea with much enthusiasm and offered useful suggestions on the course's outline, objectives, target audience and ways of implementation.

Following that, the EEL/NKUA team consisting of Maria Daskolia, Naya Grillia, Evi Kakaroucha and Dimitris Gkotzos, proceeded in a series of preparatory **actions**:

- They first explored **alternative options** with regards to the mode of implementation most convenient and appropriate for the training course (face-to-face vs. distance/online training, synchronous vs. asynchronous learning, etc.), taking into consideration the special circumstances and uncertainty surrounding the COVID-19 pandemic and how it has affected the education sector.
- An official **application form** was prepared and submitted to the NKUA's **Center for Continuous Education** (CCE) requesting permission and technical support for the creation and delivery of the course on the CCE's online educational platform (eClass platform). The application included the rationale and aim of the course, and a detailed description of the modules, the expected learning outcomes, the prerequisites for selecting the trainees, and more information data. The CCE Board approved the request and granted access rights to the eClass platform and full technical support.
- The EEL/NKUA team set out to prepare the **training materials**, i.e., the necessary educational resources that would accompany and support the trainees' learning. The co-design and collaborative writing of the training materials were based on a thorough literature review conducted by the EEL/NKUA team that led to the production of **5 modules** and a range of **learning activity sheets**. The criteria that guided this process were that the training materials should include all necessary and accurate information as well as engage participants in constructive reflection, active and collaborative learning and critical discussion on the topics to be covered in the course.

In the meanwhile, the formal **announcement** of the online course was released together with **personal invitations** that were sent to selected teachers and other educational stakeholders, the profile of whom met the criteria for participation in the course. The announcement/ invitation outlined the purpose, plan, and duration of the course, the terms of participation and commitment and the type of certificate to be issued upon completion of the course, the deadline dates for applying and the relevant link to express their interest (tinyurl.com/cos4cloud). Having collected all applications the NKUA team preceded to the selection procedure. The results were announced to all successful candidates together with instructions on how to **register on the e-learning platform**. Prior to the course's commencement and the scheduled first online meeting the participants were asked to complete a "Introductions and Get-To-Know Questionnaire".

2.4. Participants

From the twenty-three selected to participate in the online training course twenty-two successfully completed it. More specifically, the course's participants were:

- Six primary education teachers
- Five secondary education teachers
- Three primary and secondary environmental education project coordinators
- Nine environmental educators and teacher trainers based in Environmental Education Centers

Eighteen participants were women and five were men. They were all experienced environmental educators or in other long-tenure positions serving school-based EE/ESD. With regards to their scientific background and other professional qualifications, they had all completed undergraduate, postgraduate and/or doctoral studies in the following areas:

- Education (7 trainees)
- Greek Language and Literature (3 trainees)
- English Language and Literature (2 trainees)
- Agricultural/Geology/Environmental Sciences (4 trainees)
- Architecture/Engineering (2 trainees)
- Mathematics/Biology (4 trainees)

In terms of their **personal incentives to participate in the course**, the trainees completed a questionnaire constructed and administered via the eClass platform before the start of the course. Based on their responses:

- 8 were interested in exploring new perspectives in their EE/ESD practice
- 6 said they were looking for professional development opportunities to come across new ideas, methods and tools and to get inspiration for their teaching practice
- 8 answered that they wanted to better understand the connection between citizen science and EE/ESD
- 4 participated out of interest to gain new experiences and for networking.

2.5. Methodology of the online training course

The initial plan was that the training course would be based on a blended training model, combining face-to-face meetings and asynchronous distance education. This model would allow trainees to actively participate, each at their own pace and according to their preferred learning style as well as offered many opportunities for collaborative work. However, due to the measures enforced to limit the spread of Covid-19, the course was run entirely online hosted on the NKUA's CEE asynchronous education platform (open eClass) (**https://eclass.cce.uoa.gr / courses / CCEHUMAN121 /**).

The NKUA has a long-standing tradition and experience in lifelong learning and training. For over 20 years now, it designs and delivers **formal and non-formal education and training programs** in more than 400 thematic fields. The NKUA's **Open eClass** platform (https://eclass.cce.uoa.gr) has all necessary **technical characteristics** to ensure compatibility with all browsersand a customizable user interface. Moreover, it complies with all e-learning standards and offers many functionalities for the creation and management of educational content, the allocation of different user roles, the use of various communication, collaboration, feedback and evaluation tools, etc.

The implementation of the Cos4Cloud project's online course "**Environmental Education for Sustainability and Citizen Science**" (Fig. 3) comprised the following two categories of **learning activities**:

a) **asynchronous learning activities**, including individual study of the training materials, participation in discussion forums, the completion of questionnaires and self-assessment tasks, and the co-design of educational scenarios and activities.

b) **synchronous learning activities**, including the online scheduled meetings in the plenary for feedback, evaluation and debriefing, online collaboration meetings within the working groups and participation in dedicated webinars, such as the "Tackle odour pollution with OdourCollect", "Monitoring plant biodiversity with Pl@ntNet", or "Create your own air quality sensor with CanAir.io!",

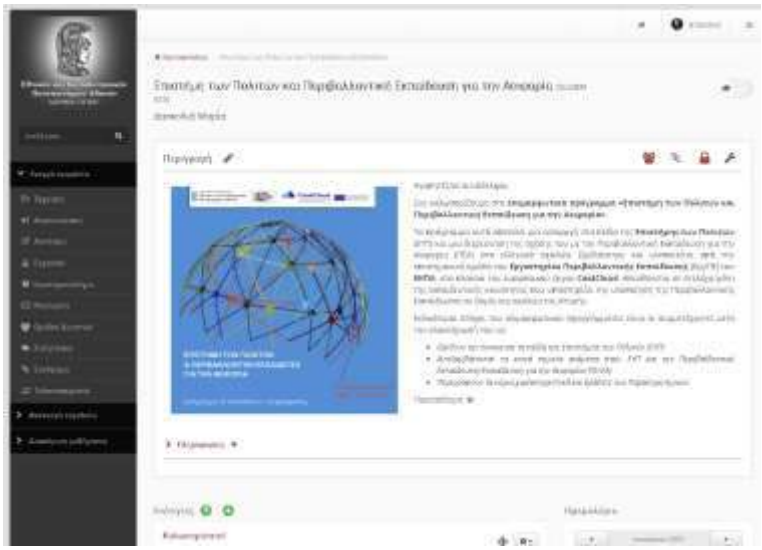

Figure 3: The online course in the NKUA's eClass platform

The online **kick-off meeting** was synchronous and took place in early July 2020. At the onset the trainers' team presented the Cos4Cloud project and its ambitions. They described the course outline, its aims and rationale, and demonstrated the use of the eClass platform and how the course will be run on it. They also gave guidelines on how to study the training materials developed for use in this course, how to participate in the various learning activities, the expected learning outcomes, the types of coursework foreseen and the trainees' assignments.

The course was designed to follow a sequence of three phases:

- Phase A: Guided weekly tutorials on the platform that covered **4 theoretical modules** and were accompanied by a set of proposed tasks and exercises for the participants (duration: from July to August 2020).
- Phase B: Organization of **two webinars,** the first webinar on how to use Pl@ntNet (with Inria) and the second on how to use OdourCollect (with ScienceforChange). The purpose was to demonstrate the use of two Citizen Observatories and explore their

potential for school use and learning as an intermediate step before participants proceed to the last phase. Phase B concluded with a synchronous online meeting where all trainees were invited to share their experience and evaluate their learning so far, as well as in order to discuss with them the next steps and goals (duration: from September to October 2020).

- Phase C: A **practice-oriented module** (5th module) where the trainees were invited and mentored to co-design and develop their **educational scenarios**. This phase concluded with a final synchronous online meeting in which trainees presented their scenarios and received feedback from their trainers and co-trainees (duration: November - December 2020).

Upon successful completion of all three phases of the online course, participants received the **Training Certificate** and the **Europass Certificate Supplement (**total **ECVET points: 4)**.

2.6. Expected learning outcomes

The expected learning outcomes achieved which are featured on the **Europass Certificate Supplement** granted to all participants who successfully the completed the course related to the development of **content knowledge, skills, attitudes & behaviours**. More specifically, participants were expected to develop:

a) Content knowledge in the following areas:

- Citizen science as a concept and practice
- The common features between Environmental Education/Education for Sustainable Development and citizen science
- The main characteristics of the Citizen Observatories (CO) for biodiversity and environmental quality protection and their field of actions
- The main CO platforms, applications, and tools of the Cos4Cloud project
- Ways in which citizen science contributes to the 17 Goals of Sustainable Development
- Teaching and learning goals to foster citizenship in students of different educational levels and grades
- Teaching and learning objectives to foster the students' participation and engagement in scientific research processes
- Teaching methods that can be employed in the integration of citizen science into EE/ESD projects and activities
- Pedagogical design of citizen science school-based activities

b) Skills in relation to

- The transfer of theoretical knowledge about citizen science into educational practice
- The design of citizen science school-based activities within the context EE/ESD projects
- The use of the Cos4Cloud'sCO platforms, tools, and applications for biodiversity recording and identification

- The use of the Cos4Cloud'sCO platforms, tools, and applications for environmental quality monitoring
- The transfer of educational design theories into the co-design of educational resource aiming to integrate citizen science into school-based EE/ESD practice

c) Attitudes/behavioural dispositions related to

- Personal engagement in school-based citizen science activities within the context EE/ESD projects
- Becoming agents of change with a multiplying effect for expanding school-based citizen science in the wider educational community
- Becoming agents of change for sustainability in the local communities through school-based citizen science
- Advocate the idea of open science and public participation through citizen science
- Promote the Sustainable Development Goals through citizen science participation

2.7. The online course's training materials

The training course was structured in **five modules**. For each of them the NKUA team co-created relevant training materials. More particularly, the training materials included:

(a) For each of the four **theoretical modules,** a customized introductory text ('chapter') for reading was co-authored by two members of the NKUA team. Each 'chapter' set the general conceptual frame, defined the basic concepts and presented different approaches to the topic it dealt with and related issues. The aim of each 'chapter' was to gradually introduce the topic of each module to the trainees by covering a range of perspectives and progressively build on a fundamental theoretical knowledge necessary for the design of the educational scenarios. The content of each text was based on an extensive literature review. Suggestions for further reading and information sources (research studies, articles, legislative texts, websites, etc.) were listed at the end of it.

(b) The final, **practice-oriented module** was based on the knowledge acquired in the previous theoretical modules. Through appropriately designed learning activities it attempted to engage the trainees in the collaborative design of the educational scenarios as the guiding frameworks for educational practice.

More specifically, the **five modules** covered the following topics:

Module 1: *Introduction to basic concepts, approaches, and practices of citizen science*

In this module, we aimed to **define** and **delineate** the field of citizen science. We presented various **definitions** of citizen science, reviewed **its historical course**, presented diverse ways through which **citizens are involved** in its practice, and highlighted the **factors that motivate** citizen participation. We also discussed the benefits from citizen science practice, its **guiding principles** and, attempted to frame its affinities with **education**.

***Module 2**: From citizen science to citizen observatories - supporting environmental protection in practice.*

This module aimed to highlight the organic connection between **citizen science** and **Citizen Observatories (CO)** in the context of biodiversity monitoring and environmental quality, the two main fields of citizen science practice promoted by the Cos4Cloud project. We analyzed the **concept,** the **scope** and the **basic dimensions** and **features** of modern COs and listed a range of prominent **COs in Europe**. We finally discussed how citizen science and the COs serve as valuable **tools for biodiversity monitoring** and for **environmental conservation and protection**.

***Module 3**: The Cos4Cloud European project: Addressing the challenge of open science through citizen science*.

In this module we presented the **European project Cos4Cloud**. We started from discussing **'open science'** as an idea and practice that promotes the democratization and facilitation of scientific research and we went on with the contribution of **citizen science** to open science. The Cos4Cloud project and how it attempts to meet the challenge of open science was then presented. We described the project's **vision**, its **objectives** and main **axes of action** and highlighted the benefits from integrating **Citizen Observatories (CO)** into the **European Open Science Cloud (EOSC)** through networking and the development of new services. We also introduced the **project's partners** and participating **Cos** and outlined the role and contribution of the **NKUA** to the project.

Figure 4: Page extracts from the Modules' texts.

***Module 4**: Citizen science and school educational practice in the context of environmental education/ education for sustainable development*

The aim of this module was to explore the **relationship** between citizen science and education, by focusing on its **synergies with Environmental Education (EE) and Education for**

Sustainable Development (ESD). To this end, we identified the fields where citizen science meets EE/ESD, as well as their **common characteristics**. Possible **ways of integrating citizen science** into the school practice were examined and the learning and other gains from such integration were considered. The prerequisites for an effective and meaningful integration of citizen science into school practice were also suggested. Finally, discussion focused on the **impact** of incorporating citizen science into school-based EE/ESD school practice. The module concluded with various examples of citizen science projects implemented in schools and one school case study which was based on the use of Pl@ntnet.

Module 5**:** *Co-design of educational scenarios for the integration of citizen science into school-based EE/ESD practice.*

In this final module, participants were invited to take the role of 'educational designers' and co-design educational scenarios and activities that aimed to integrate citizen science and EE/ESD into school educational practice. To this end they were handed an '**educational scenario template'**, which was constructed by the NKUA team. Then they were divided into six groups of three to four persons. Their task was to co-create an educational scenario that makes use of either Pl@ntnet (three groups) or OdourCollect (three groups). Three groups worked on educational scenarios appropriate for use with students in primary education school level and the other three groups for students in secondary education school level.

2.8. Support and facilitation of the co-design process

Throughout the online course the NKUA team offered continuous support to the trainees through the **eClass platform** and its various tools. More specifically, support and facilitation were provided through the following platform's areas:

- **Announcements -** A total of 50 announcements were posted by the trainers' team.
- **Asynchronous forum discussions -** In total, forum discussions were commenced and carried out over 7 topics, through which the participants uploaded a total of 114 posts.
- **Questionnaires** - through which participants had the opportunity to express their preferences, share evaluative comments, etc. In total, 98 completed questionnaires on 6 topics are recorded.
- **Exercices and assignements -** Trainees were invited to take part in self-assessment activities of their comprehension and application of the knowledge gained from the various modules.
- **Documents -** In total, 31 files were uploaded in shared folders including the training materials and more proposed readings and other resources.

In addition to the eClass online platform, the trainees received support from the trainers' group on the following occasions:

- during the synchronous online plenary meetings (the kick-off meeting: 1/7/2020, the mid-term meeting: 23/10/2020 and the debriefing meeting: 19/3/2021

- through the electronic communication exchanged between the trainers and the members of the 6 working groups, that offered personalised support to the co-design processes

- through the feedback the trainers provided to the working groups in the form or ppt presentations during the debriefing meeting. The presentations are available here: https://drive.google.com/drive/folders/14e4UBC67-UwgGF-ByNKeTXjQ-Bw0KL7i?usp=sharing

- through the organisation of webinars to introduce and familiarise the trainees with selected COs of the Cos4Cloud project. In particular, the following webinars were organised in cooperation with other project partners:

a) "**Tackle odour pollution with OdourCollect**", on 30/9/2020 (17.00 - 18.15p.m.) in collaboration with **Science for Change** (https://www.youtube.com/watch?v=uTb6Y_7eSnA&t=7s)
b) "**Monitoring plant biodiversity with Pl@ntNet**", on 12/10/2020 (17.00 - 18.30 p.m.) in collaboration with **INRIA** and **CIRAD** (https://www.youtube.com/watch?v=Wv-3Qf_4KEE&t=3130s)
c) "**Create your own air quality sensor with CanAir.io**", on 18-11-2020 (21.00 - 22.15 p.m.) in collaboration with **SciStarter** and **CanAirIO** (https://www.youtube.com/watch?v=q5ZzWJP9PJs&t=2017s)

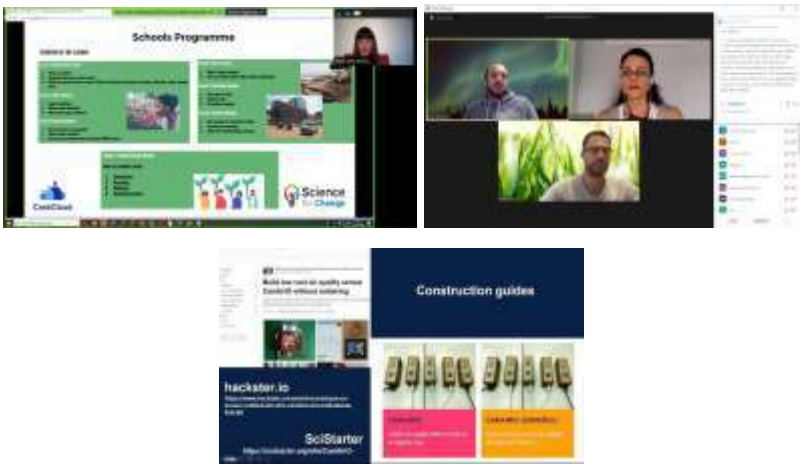

Figure 5: Screenshots from the webinars organized

2.9. Online course evaluation methodology

Evaluation was an internal part of the design and implementation of the online course "**Citizen Science and Environmental Education for Sustainability**". The multi-dimensional nature of citizen science and EE/ESD and the complexity of the goals they set forth, often pose various challenges to the designers of training programs and materials at different levels, including their evaluation (Granit-Dgani, Kaplan & Flum, 2017; Stern, Powell & Hill, 2014; Brody & Storksdieck, 2013; Carleton-Hug & Hug, 2010). Evaluation is a key tool for ensuring the quality of the education provided and the associated learning (Bray, 2008). It also aims to better understand

and improve educational practice by matching it to the goals and intended outcomes (Zint, Dowd & Covit, 2011; Birnbaum, 2010; Jenks, Vaughan & Butler, 2010).

Monroe & Jie-Li (2013) describe three types of evaluation in non-formal adult education and training programmes, based on the timing and duration of the evaluation in relation to the course delivery. These include the *front-end*, the *formative* and the *summative* evaluation. Of the three, they single out **formative evaluation** as the type of evaluation that can provide meaningful feedback on various aspects, thus increasing the chances for the evaluated training program or materials to meet the standards on which they have been designed.Formative assessment is particularly useful as it prevents training course designers to deviate from their predefined goals and objectives. Moreover, it facilitates the follow-up of the course's progress and adds to its improvement while it's been implemented by engaging participants in reflection.

More specifically, the online course's formative evaluation was carried out at two levels:

1) At a first level, it was based on **an internal ongoing process of reviewing and updating the design of the online course and the supporting training material**. The NKUA team who designed the online course and the training materials was mainly involved on this level. The data collected was qualitative in nature and were extracted from the following two sources:

a) The **discussions within the trainers' team**, which served as a space for reflection and sharing on the design and organization of the training course and the training materials. These discussions took place throughout the co-design process and formed the baseline for planning and carrying out all training activities.
b) The **electronic messages exchanged between the trainers**. These messages complemented their communication in between their regular meetings and provided a second space for exchange and reflection on the progress of the design process.

In relation to the evaluation of the educational material, the approach taken was based on the one developed by Russo & Olvitt (2006) for the design and evaluation of "quality" educational material, using as criteria some "general principles", which guided the training team not only for the design of the educational materials, but also as a rationale behind the design process of the training course as a whole.

2) At a second level, formative evaluation was carried out **during the implementation process** to assess whether the course met the design criteria and the expectations of the participants and to record the participants' individual responses to the various activities.

At this level, qualitative and quantitative data were obtained and analysed from: a) **a set of questionnaires** administered and completed by the trainees on the eClass platform at different stages of the course's implementation; and b) the **discussions** the trainees participated on the eClass discussion forum. The trainees were invited to provide their responses to close and open-ended questions about their personal background, their needs and expectations and to comment and/or reflect on issues related to the course's content, the Cos4Cloud technologies and other topics raised in the course. In addition, the trainees participated in assessment tasks and exercises designed by the NKUA team to give them a feedback about their degree of comprehension of new concepts and contested issues and how well they could transfer

theoretical knowledge into practice based on the knowledge they had gained and the instructions they had received.

It is worth mentioning that these two levels of evaluation were not isolated and disconnected phases the one from the other. Instead, they were two intertwined levels of evaluation that traversed horizontally all dimensions of the online course. They started from the co-design phase, followed the implementation phase and extended beyond it, to the evaluation of the learning potential and the educational impact of the course, i.e. by tracking the responsiveness of the online course to the school reality. In fact, it was a spiral process of evaluation, a central feature of which is that it is ongoing and reflexive and evolved as follows: *design; experimentation; evaluation; adaptation; revision; re-design*.

2.10. Examples of evaluation tools used and their results

Various tools of evaluation were used to collect data on a range of issues over participation in, responsiveness to and effectiveness of the online training course. For example, **online questionnaires** were constructed by the NKUA team and employed for collecting different sets of data, such as to record and assess the participants' profiles and background, the level of satisfaction from the course and their intention to transfer and apply the acquired knowledge to their school practice. Results were used in the initial design of the course, to plan next steps and incorporate new training activities or for redesigning aspects of the course's content and structure. They were also used to compare the teachers' level of perceived readiness to engage with citizen science practice before and after the implementation of the course as an indicator of the effectiveness of the training and in order to plan the following actions.

For example, the two questionnaires listed below were used at the start and after completion of the course respectively. Results from the first questionnaire showed that most of the participants had no previous experience with citizen science at all. Nevertheless, after having undertaken the course, they all expressed their commitment to get involved with citizen science and implement the educational scenarios they developed into their school(s) (second questionnaire):

1. <u>Questionnaire before the start of the online training course</u>

- **Aim**: to record the participants' profile (demographic information: gender, age, education, job position, their previous experience in EE/ESD, their previous experience in citizen science, etc.), their understanding of citizen science and their views about its integration into school education, their motivation for participating in the training course and their expectations from it, their level of familiarization with the open Eclass platform, etc.
- **Number/ types of question items**: 29 open and multiple choice questions
- **Answered questionnaires**: 23
- **Link**: https://eclass.cce.uoa.gr/modules/questionnaire/pollparticipate.php?course=CCEHUMAN121&UseCase=1&pid=6

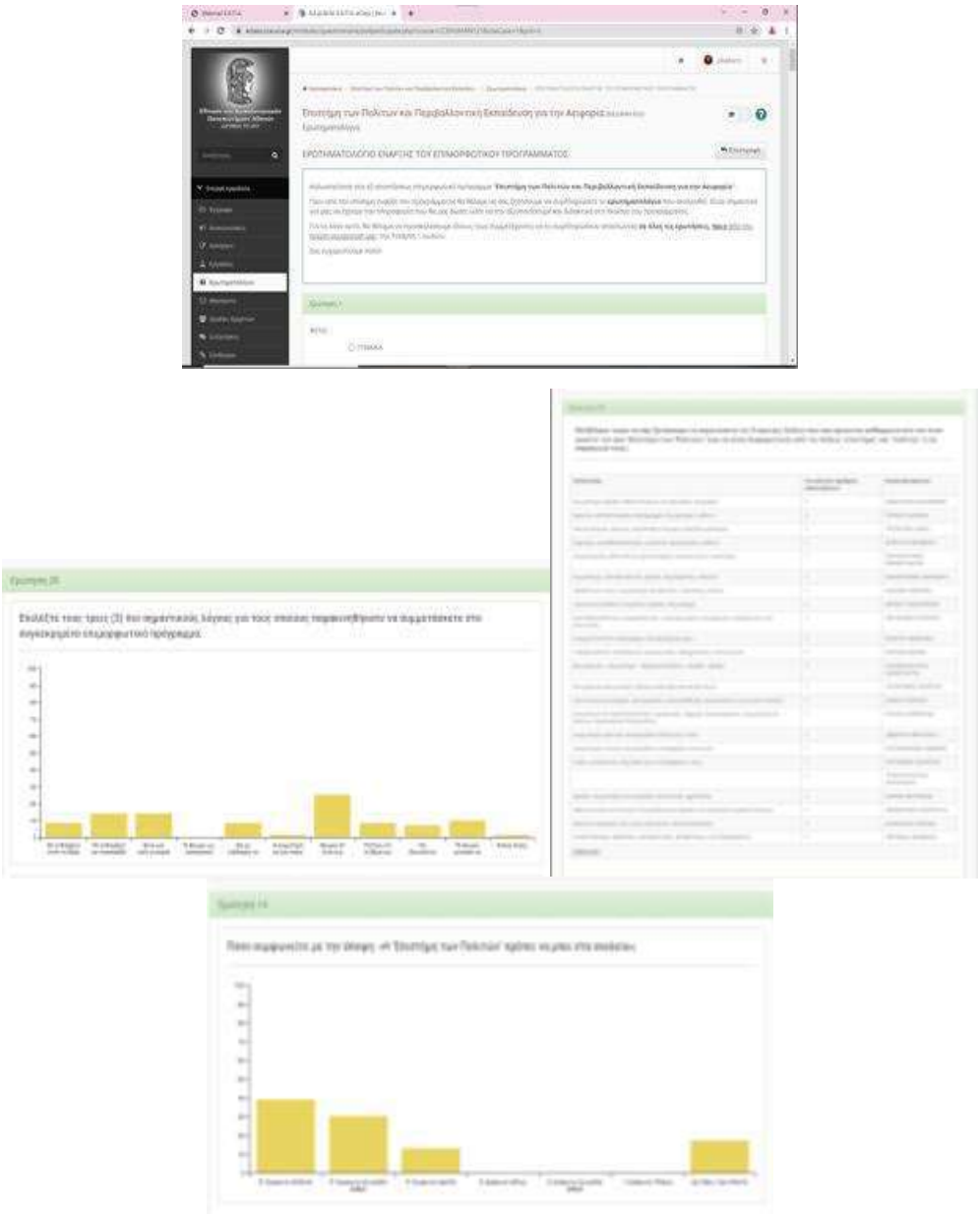

Figure 6: Screenshots from the online Questionnaire 1 and data analysis graphs

2. <u>Questionnaire on the participants' intention to implement the educational scenarios and activities</u>

- **Aim:** to record the participants' intention to implement the educational scenarios and activities developed during the training course for the period April-May 2021 and the school year 2021-2022, as well as their intention to present or inform other teachers about the scenarios or to collaborate with other teachers to implement them
- **Number/ types of question items** 19 open and multiple choice questions
- **Answered questionnaires**: 18

- **Link**: https://eclass.cce.uoa.gr/modules/questionnaire/pollparticipate.php?course=CCEHUMAN121&UseCase=1&pid=16

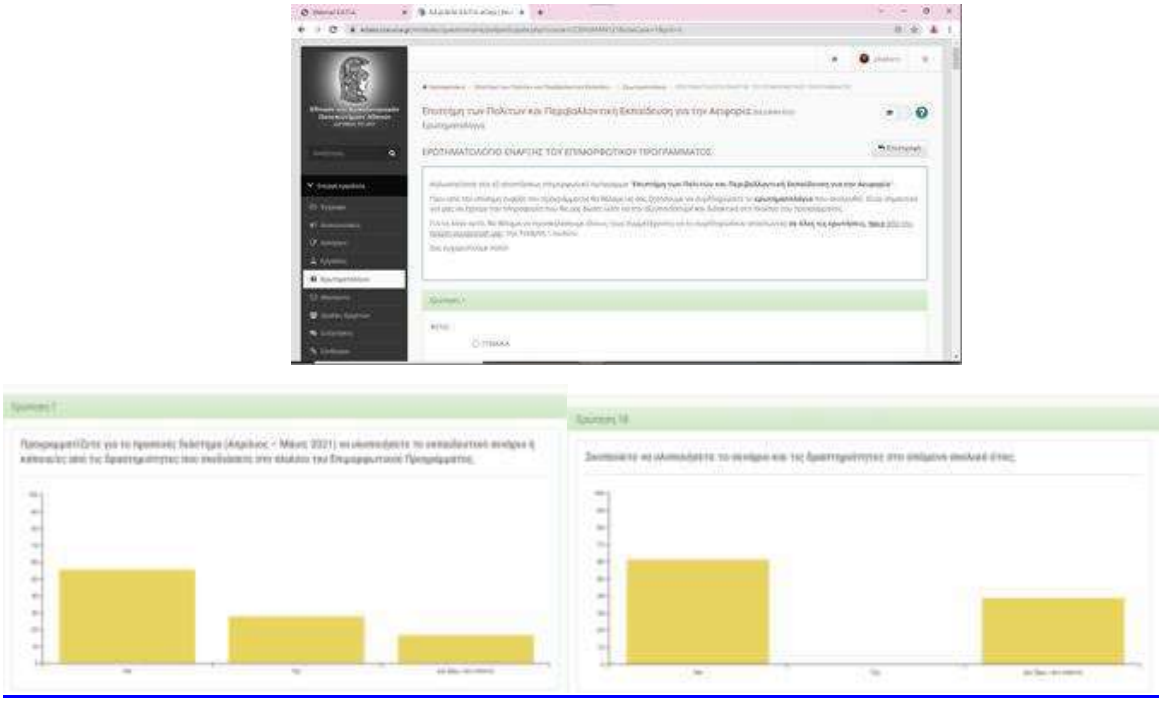

Figure 7: Screenshots from the online Questionnaire 2 and data analysis graphs

Another example of questionnaire is described below. It was used after the organization of two webinars, which introduced trainees to the use of two citizen observatories respectively: Pl@ntNet and OdourCollect:

3. Questionnaire for the evaluation of the two webinars

- **Aim**: to assess the extent of the trainees' satisfaction from their participation in the two webinars ("*Tackle odour pollution with OdourCollect*" & "*Monitoring plant biodiversity with Pl@ntNet*"), which were organized as part of the online training course, as well as the degree to which they believe they will be able to use the acquired knowledge for the implementation of school-based educational activities
- **Number/ types of question items** 16 multiple choice questions
- **Answered questionnaires**: 21
- **Link**: https://eclass.cce.uoa.gr/modules/questionnaire/pollparticipate.php?course=CCEHUMAN121&UseCase=1&pid=12

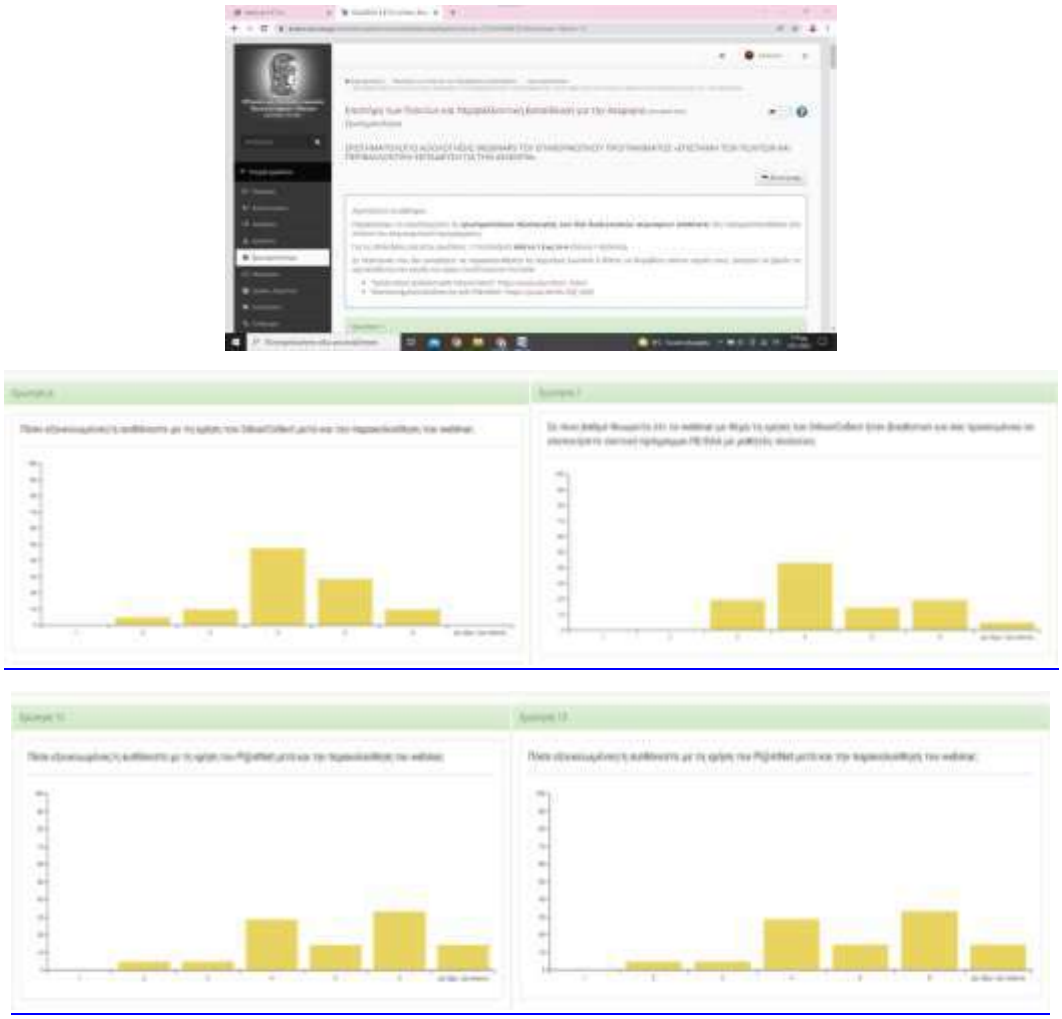

Figure 8: Screenshots from the online Questionnaire 3 and data analysis graphs

As far as the participants' overall satisfaction with the two webinars, **the majority rated them quite favourably**. Both were considered to have the potential to support citizen science projects and activities. Participants were also asked after attending the webinars to rate their level of familiarization with the two apps. About two thirds felt quite comfortable with OdourCollect and Pl@ntNet alike. Finally, regarding the extent to which participants felt the two webinars helped them implement a relevant project with school students, their preferences for Pl@ntNet had a relative advantage over OdourCollect.

Data were also collected in the context of specific training activities about **the participants' use of the various citizen observatories**. In one training activity they had to register and to use each of the project's citizen observatories. Following this trial use, they were asked to evaluate them and declare their preferences to using them as teaching and learning tools. The analysis of their responses indicated that Pl@ntNet was closer to the trainees' personal interests and the one they would be willing to engage with as citizen scientists. It was followed by Natusfera and Freshwater Watch.

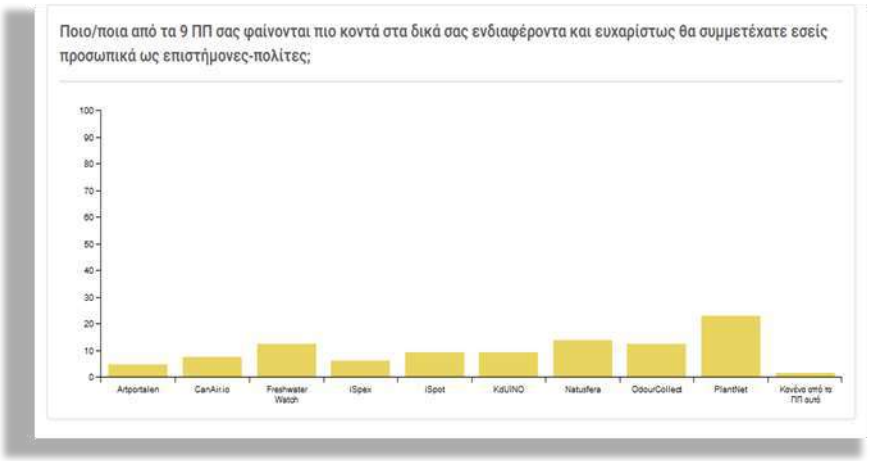

Figure 9: Data analysis graph on the trainees' preferences on the COs.

Pl@ntNet and then Freshwater Watch ranked first in terms of the trainees' evaluation of their appropriateness for pedagogical use in classroom and outdoor educational activities, as shown in Figure 10:

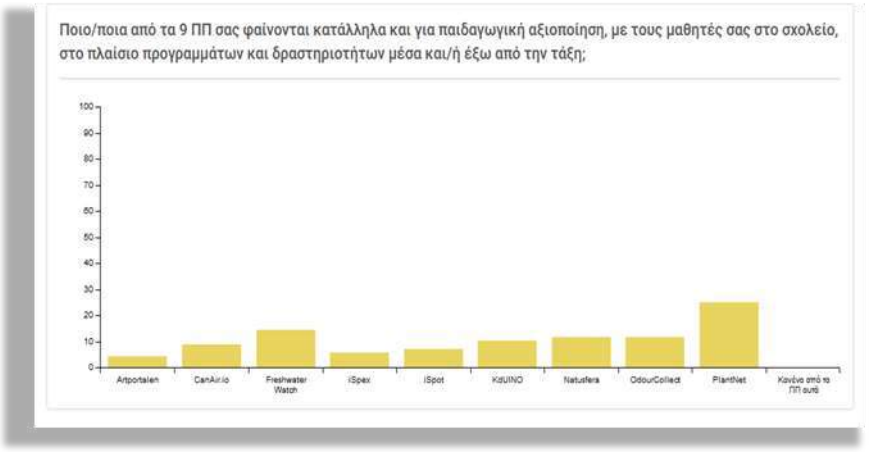

Figure 10: Data analysis graph on the trainees' perceived appropriateness for pedagogical use of the COs

All teachers registered to the platforms of all citizen observatories without any particular difficulty to a greater or lesser extent. Their registration was most successful regarding Pl@ntNet and Natusfera. Pl@ntNet was also higher in the teachers' expressed intention to attend extra training seminars.

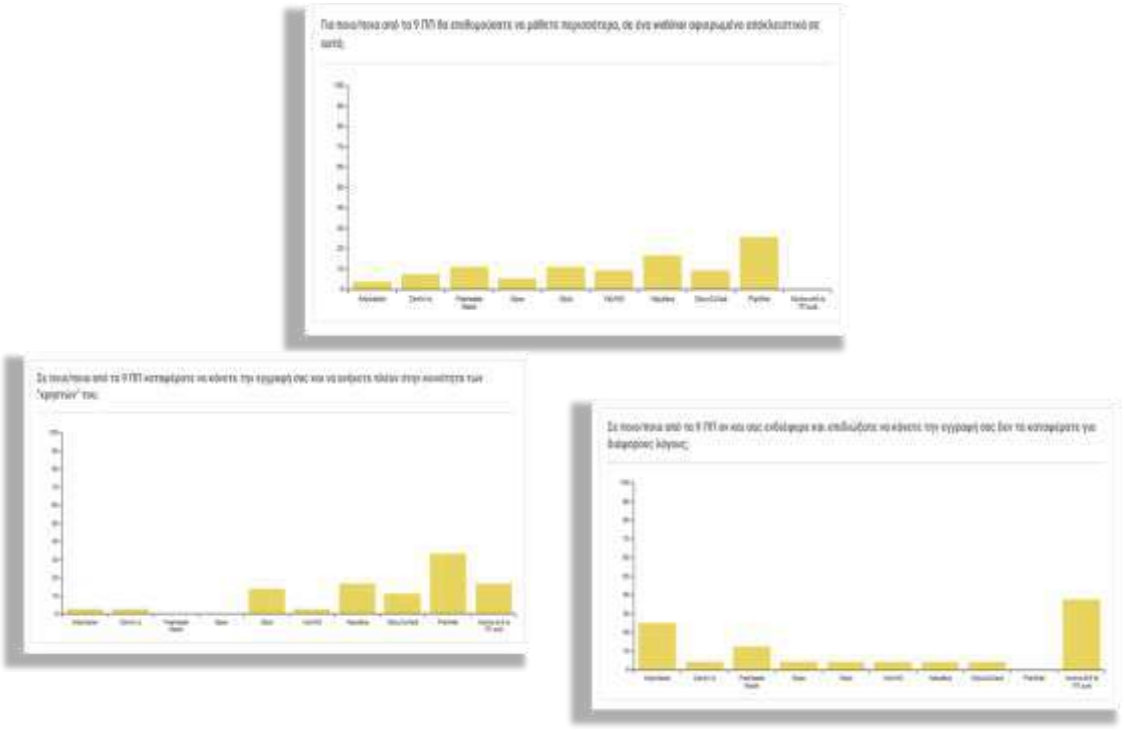

Figure 11: Data analysis graphs on the trainees' perceived easiness to register and intention to attend training seminars on each of the COs

Finally, evaluative evidence of a more qualitative nature was also collected in the form of **short videos** the participants created and send to the NKUA to talk about and share their experience. Some of their evaluative statements and digital stories can be found in the following post in the project's Newsletter:"What do the NKUA course's participants think about the training on citizen science? Read the statements and watch the videos!".

2.11. Overall appraisal of the online training course

Based on the evaluation carried out, the teachers and educational stakeholders who participated in the online training course had the opportunity to get acquainted with the theory and practice of citizen science, the Cos4Cloud's citizen observatories and their technologies, and the project's goals and ambitions. Through the training materials, their interaction with their fellow trainees, the NKUA trainers and the other Cos4Cloud partners, the participants realised the common points of interest between citizen science and school-based EE, as well as the ways in which the former can be integrated into the latter. They committed themselves to undertake actions in their schools and fields of responsibility. Their commitment was initiated through involvement in the co-design of educational activities and projects making use of selected Cos4Cloud's citizen observatories and tools. The aim was that these scenarios would become a 'roadmap' for educational practice, providing inspiration and guidance to the members of the upcoming thematic Educational Network.

All facets and steps of the implementation and evaluation of the online training course was designed and carried out in a way to serve and foster a culture of creativity, teamwork, collaboration, mutual support and acknowledgment among participants, as well as a feeling of being part of a community with defined goals, openness and ambition to remain in place well beyond the completion of the Cos4Cloud project.

Some of the structural elements of success of this training course in terms of how it was designed and implemented based on the principles and practices of open science and citizen science promoted by the Cos4Cloud project, are the following:

- **the deliberate configuration of a diverse group of trainees,** selected to represent different disciplines, professional backgrounds, personal aspirations and stages of personal/ professional development;

- **the creation of ample opportunities for participation in online discussion forums,** that fostered reflection and the exchange of ideas and opinions among trainees;

- **the provision for several collaborative and mentoring sessions** held in groups and/or in plenary contexts;

- **the organisation of dedicated webinars with the active participation of trainees** to familiarize them with the use of CO platforms and tools, and, most importantly, to build their readiness to integrate them into school practice;

- **the promotion of practice-oriented collaborative learning through the co-design** of educational scenarios and activities;

- **the sharing of educational scenarios** with other trainees as well as **the promotion of constructive feedback** that led to their refinement and alignmentwith the goals of the online course and the Cos4Cloud project;

- **emphasis on direct transfer and adaptation of acquired knowledge into school practice**, with due consideration to the conditions imposed by the Covid-19 pandemic;

- **the dissemination of the rationale, results, and applications of the training course** in professional development activities and events and on the social media.

3. THE SCHOOL EDUCATIONAL NETWORK

3.1. Introduction

The existence of a thematic educational network helps to foster teaching and learning in a educational area or in relation to a specific topic of interest. It offers teachers many opportunities to come together, interact and collaborate and to build new insights and skills in their educational practice. It becomes a context for professional learning and development that enhances dialogue, partnership and the building of joint activities, including the production of educational resources and the implementation of educational projects in schools.

In EE/ESD, thematic educational networks provide a communication and collaboration milieufor students and teachers from different schools and districts to meet and work, as well as the possibility for setting up an integrated scientific and pedagogical approach to specific environmental topics. They also support and facilitate the realisation of educational innovations in schools. In Cos4Cloud project we argue that the creation of an educational network with a focus on integrating citizen science into EE/ESD offers a range of advantages and adds to its success. To this end, the establishment of **a thematic educational network on "Environmental Education for Sustainability and Citizen Science"** was deemed as an critical parameter of the Design Model and a constituent part of our approach.

3.2. Establishment of the first educational network

The educational network "**Environmental Education for Sustainability and Citizen Science**" was initiated with the call for expression of interest for teachers and other educational stakeholders to participate in the online training course. The invitation was addressed specifically to Greek teachers and stakeholders in EE with a long-standing and influential record as educational practitioners in the field and with previous involvement in partnerships (e.g., with other teachers, educational researchers, scientists, citizens and representatives of the civil society, public administration and local authorities, etc.).

With the launch, and more particularly with the completion of the online training course, the **first educational network** was established, consisting of **23 members**:

- 6 primary education teachers,
- 5 secondary education teachers,
- 3 primary and secondary environmental education project coordinators,
- 9 environmental educators and teacher trainers based at Environmental Education Centers

Because of the small number of members and the homogeneity in their identity as participants of a professional training course this first network had more the status of **a community of learning and practice**. The majority of the members were women, school teachers with a long-tenure experience in EE/ESD. Most of them had pursued postgraduate studies in education and other disciplinary fields.

The Network's first meeting took place in the final synchronous online session of the course. In this meeting the participants discussed about the actions each of them, in person or in cooperation with others, would be willing to implement in schools and those they could contribute to attract more teachers and expand implementation of citizen science projects in schools.

3.3. Communication activities to open up the educational network

Among the efforts to expand the initial community of practitioners and attract new members for the Network were the communication activities organized by the NKUA to address the Greek school community of EE/ESD. Indicatively we list the participation of the NKUA's team members in the following events:

1. At the **8th Conference of the PanHellenic Association of Teachers for Environmental Education**, where the NKUA team gave a presentation on "Citizen Science, European Open Science Cloud and Environmental Education in the COS4CLOUD project" (12.9.2020). The presentation was attended by more than 180 school teachers, researchers, NGO educators and representatives of local authorities involved in the practice of Environmental Education throughout Greece.

2. At the teacher training webinar titled "**Greening my school, greening my city. Pedagogical approach and digital tools**" organized by the CEE of Elefsina on the 28.1.2021 in collaboration with the primary and secondary environmental education project coordinators in B and C Athens and Western Attica Education Districts, where the NKUA team gave a presentation on "CS meets EE/ESD in schools: pedagogical use of Pl@ntnet in school garden and urban greening projects". The webinar was attended by 122 teachers.

3. At the teacher training webinar "**Medicinal and aromatic plants in our lives**", organized by the CEE of Lavrion on the 30.3.2021 in collaboration with the primary and secondary environmental education project coordinators in B Athens and Eastern Attica Education Districts. The NKUA team participated with a presentation on "Recording aromatic plants and herbs and their stories. Interdisciplinary ideas for EE practice based on citizen science approaches and tools". The webinar was attended by more than 120 teachers.

4. At the teacher training webinar on: "**Cultivating new skills and environmental awareness in the school garden**", organized by the primary and secondary environmental education project coordinators in B and C Athens Education Districts on 30.11.2021. The NKUA team participated with a presentation on: "Citizen Science in the school garden. Ideas and suggestions for educational activities with Cos4Cloud Citizen Observatories". The webinar was attended by 80 teachers.

5. At the teacher training webinar on: "**Connect with nature**!", organized by the CEE of Eleftherio-Kordelio & Vertisko and the CEE of Kilkis on the 16.12.2021, in collaboration with the primary and secondary environmental education project coordinators in B and C

Athens Education Districts of Eastern and Western Thessaloniki. The webinar was attended by 420 teachers. In this event the NKUA team announced the establishment of the thematic school network “Environmental Education for Sustainability and Citizen Science” and presented its website which is under-development. Interested teachers were invited to register and join the network after the formal call was released in early 2022.

3.4. Towards a nationwide educational network

The efforts of the NKUA team to promote the school-based practice of citizen science among the Greek educational community and in line with the Cos4Cloud project’s objectives begun with the online course. This is where the first community of learning and practice was established. The growing interest expressed by more school practitioners on the occasion of the NKUA’s dissemination actions strengthened the idea to go beyond the this rather small community to **a nationwide Educational Network** on "Environmental Education for Sustainability and Citizen Science" under the coordination of the NKUA’s Environmental Education Lab (EEL). The network’s mission would be to establish partnerships and to pursue mutual benefit for citizen science and EE/ESD alike in the school and local community contexts. Moreover, the aim would be to nurture motivation and foster learning through science and social participation in students so as to become empowered as young citizens in the face of current sustainability challenges.

To strengthen these efforts for developing this nationwide educational network "**Environmental Education for Sustainability and Citizen Science**" (**EECSnet**), the design, construction and operation of a website was considered of strategic significance. Among the essential features of effective educational networks identified by Rincon-Gallardo & Fullan (2016), are adequate resources, the potential for frequent connection outwards and inwards and the creation of new partnerships. The development and operation of **a website** can function as supporting infrastructure for an educational network, offering all three of these features. It can serve:

- as a repository of educational resources, through collecting, organising and sharing relevant educational materials that have been developed, tested and evaluated, as well as best practices,
- as a point of reference for all interested parties by providing easy and immediate online access for people outside the Network and enabling communication between the Network’s members, thus serving frequent connection outwards and inwards,
- as a context for the development of new partnerships.

This decision to create a website for the Network led to a series of actions, including:

1. the quest for and creation of a **domain name**. This was selected to be based on the initials of the Network’s title (eecs-net) and inform about the organization in charge of the coordination, i.e., the University of Athens (uoa): **eecs-net.eds.uoa.gr** (http://eecs-net.eds.uoa.gr/).
2. the choice of a free and open source CMS (Content Management System) software,which was decided to be **WordPress**, for constructing it. The selection criteria

were the software's modern aesthetics, ease of use, scalability, user-friendliness in search engine and the fact that it offers a responsive design for adaptation to any devices (for tablets, smartphones, wide screens).

3. The **first version** of the design of the **drop-down navigation menu**, composed of 5 basic items (webpages) and more sub-items (Fig. 12). The specific items (webpages) that will be displayed in the main menu are the following:

- **The Network**: in the options of this drop-down sub-menu users can have access to webpages containing information about the educational network, the coordinating organization, citizen science, the citizen observatories and the Cos4Cloud project. The webpages will further contain links to more websites which are related to the Network.
- **Members:** In this drop-down sub-menu, users can have access to web pages containing information about the partner schools, educational districts, NGOs and collaborating scientific and local actors. The terms of membership are also described and a sign-up form is provided.
- **Educational resources:** In this drop-down sub-menu users can have access to the Network's educational resources, to a Library where additional resources related to the Network's themes are available; and to Actions, where information about activities and best practices of the Network's members will be presented.
- The **News** webpage will feature the Network's latest announcements in the form of articles or stories, marked with labels and tags for better organization of the content.
- The **Contact us** webpage will provide all the contact details of the Network as well as an online contact form.

Finally, through an add-on (plugin) there will be connection with the most popular **social media** (Facebook, Twitter, LinkedIn) and social sharing buttons for sharing posts will be provided.

Figure 12: Screenshot of the Network's website under construction

4. EDUCATIONAL SCENARIOS

4.1. Introduction

The term '**educational scenario**' is subject to many definitions. According to Khaldi et al (2020), an educational scenario offers an approach to define and achieve specific educational goals. It can be considered as a tool for describing teaching and learning activities and how to be organised and to specify the learning context and resources required for putting them into action. It also provides room for justifying the rationale for each decision taken.

A scenario is also a means for communicating an educational project to be implemented. Daele et al (2002) view it as the outcome of a process of designing learning activities that take place over a given period of time and lead to its implementation. It shares information about a range of guiding principles and conditions, such as the objectives, the sequence of phases and learning activities, the timetable, the students' tasks, the evaluation methods, all specified as part of the design process and organized into a coherent whole. According to Pernin and Lejeune (2024), "a scenario is defined as the description made a priori and a posteriori, of a learning situation aiming at the appropriation of a set of knowledge, by specifying roles, activities as well as resources, tools, services and results associated with the implementation of activities". An educational scenario specifies the targeted knowledge, the roles of the actors and their activities as well as the necessary resources, tools and services for implementing these activities.

Khaldi et al. (2020) propose that an educational scenario has four parts: a technical part that provides information about the learning situation; a part about the objectives and the knowledge and skills to be developed; a part about structuring and objectification of the learning situation through proposed learning activities; and a fourth part about transfer of the knowledge and skills to be developed in new contexts.

4.2. Methodology for the co-design of educational scenarios

An underlying principle that informed the design of the online training course was the empowerment of the participating teachers to take an active role in promoting the integration of citizen science into their schools and beyond. We applied this principle by engaging them in a second-level of learning through **Module 5** and inviting them to think and act as "**educational designers**" of citizen science projects and activities in schools. The main goal was to build on the trainees' teaching experience in EE/ESD, frame it with new knowledge and skills and involve them in the collaborative design (**co-design**) of educational scenarios and activities for school use making use of selected citizen observatories.

To facilitate co-design processes and achieve a common working basis, detailed instructions and a set of tools were provided by the trainers' team. More particularly, the NKUA designed **two templates** as the formats based on which the course participants in groups would design their educational scenarios and activities. The two templates are briefly described in the following sections. We also present the criteria for selecting the citizen observatories proposed

to the educational designers to use in their scenarios and we give an outline of the co-design process.

4.2.1. The educational scenario template

This **template** was created by the NKUA team and given to the participants to work on their educational scenarios. It consisted of **two parts** and **several subfields** to fill in, the specification of which was decided on the basis to invite them to think and share all necessary information about the rationale, technical details and course of implementation of their proposed educational project in a comprehensive and codified way. This would make it easy and transparent to understand, use, re-use or modify, and a useful and practical tool for every teacher who would like to get involved with the practice of citizen science in schools.

In the first part of the template, participants were asked to present the 'identity' of the scenario, providing information about: the main idea, what it involved, the students' target group, the key topic/issue it addressed, its duration, the Cos4CloudCO platforms/tools to be used, connections with the school curriculum, and the expected learning outcomes in terms of a range of 'literacies' and competences. In the second part of the template, participants provided a detailed description of their scenario, phase by phase, with information on: the themes, goals, steps, time and context, activities and resources involved, etc. Further instructions were given to the groups of educational designers on how to fill in each subfield and the word limit for the text they would produce.

Figure 13: The front page and a page sample of the 'educational scenario' template

4.2.2. The educational activity template

This **template** was also designed by the NKUA team in a similar way to the 'educational scenario' template. The selection of the specific subfields to be filled in was intended to provoke reflection among participants on the "identity" and the process of implementation of the two activities they would choose to present. The general outline they had to give for each activity

comprised: the title/topic, the age group/class of students, the activities' goals, the estimated time for conducting it, the Cos4CloudCO platforms/tools to be used, the rationale for how they aimed to engage students with citizen science and the possible links with the curricula and the 17 SDGs.

Subsequently, the groups of educational designers had to give a more detailed description of each activity, making reference to how they would organize the classroom, how they had envisaged the role of the teacher, the necessary infrastructure/ equipment, the supporting learning materials/ educational tools and resources, the expected learning outcomes and how they would evaluate the activity. Again, further instructions were given on how to complete each subfield and the word limit of the text they would produce.

Figure 13: The front page and a page sample of the 'educational activities' template

4.2.3. The criteria for the selection of the citizen observatories

The selection of the **citizen observatories employed** in the pedagogical design of the school-based citizen science projects and activities, which became the subject of several discussions among the Cos4Cloud project's partners during the preparatory phase of the online course, was based on more than one criterion.

The first criterion was that the selection would be among the partner citizen observatories of the Cos4Cloud project, at least one representative citizen observatory for biodiversity monitoring and one for environmental quality. The second key criterion was the issue of language: since they would be addressed to Greek school students and teachers, the recommendation was to include only those with a Greek language option. A third criterion was whether a citizen observatory had been already used with school students and the availability of training and materials and learning activity sheets.

What also stood out as important criterion for selecting which Cos4Cloud's citizen observatories to use in the co-design of educational scenarios were the preferences of the teachers and

educational stakeholders themselves, which were collected in the context of specific training activities. Their personal estimations of the degree each observatory was easy and appropriate for pedagogical use in Greek schools was also taken into account.

Based on all the above criteria, the following two citizen observatories were selected: **Pl@ntnet** and **OdourCollect**. However, participants were given the option to use any other observatory they wished from the list of those participating in the Cos4Cloud project. **Natusfera** was thus a third choice for some groups who combined it with Pl@ntnet or OdourCollect.

4.2.4. The co-design process of the educational scenarios and activities

The participants were divided into 6 groups of 3 to 4 members. The number of groups and their synthesis were decided on the criterion to lead to the creation of **six individual educational scenarios** as follows:

(a) 3 scenarios for school use in **primary** education and three in **secondary** education

(a) 3 scenarios making use of **Pl@ntnet** and three of **OdourCollect**.

The two templates were sent to the groups early November 2020. They were all given detailed instructions about the task, what it involved and how they had to work together and use the templates to generate the educational scenarios. The first step was to gather, explore and structure their initial ideas about the educational scenario they had pooled during a previous stage of their collaboration (October 2020). After that they organised a series of online meetings (e.g. via Zoom and Webex), since face-to-face meetings were not possible at the time, due to the Covid-19 pandemic measures and restrictions.

The teams used the two templates and the NKUA's instructions as frames for communicating and structuring their exchanges and co-design. Collaborative authoring was made through Google Docs. The groups allocated tasks and responsibilities and worked together until the end of December 2020. The scenarios in their final form were uploaded to the eClass platform by the end of the first week of January 2021.

In the following section we briefly present each of the six co-designed educational scenarios.

4.3. The six educational scenarios

Educational scenario 1 aims to familiarize students, who are in the last grades of **primary school**, with how to conduct citizen science with **Pl@ntNet** to study plant biodiversity in the field in two different environments: (a) the suburban forest of Ymittos (in the Attica region), and (b) their school garden. The students learn to recognize various plant species and distinguish between endemic and invasive ones; they reflect on the factors affecting the flora biodiversity (climate change, fires, deforestation, land appropriation, etc.); they create a botanical guide and a botanical path; and they get in touch with members of the scientific community to build environmental awareness. This scenario emphasizes engagement and familiarization of young learners with scientific research. Pl@ntNet is an integral part of the scenario and a tool to foster

active citizenship in primary education students and open up school education to the local community.

The environmental issue addressed in **educational scenario 2** is odour pollution in the school and in the neighbourhoods around the school. **Primary school students** are the target audience and the focus is on connecting citizen science with EE/ESD. Based on an interdisciplinary approach and making use of **OdourCollect** the scenario aims to engage students with a range of learning activities of a playful and sensory experimentation character. Students carry out sensory walks, keep odour diaries, create thematic maps and critically consider the impact of unpleasant odours on people's socio-economic life and health, their interactions with other people and the ways themselves perceive their school environment. During the implementation of this scenario, students are expected to become 'agents of change' to promote sustainability in their school and local community. The pedagogical emphasis is on exploration ('experience'), cognition ('awareness') and action. The scenario highlights and draws on the students' emotions and memories of smells in their school/ neighbourhood, to propose an 'embodied learning' approach to citizen science.

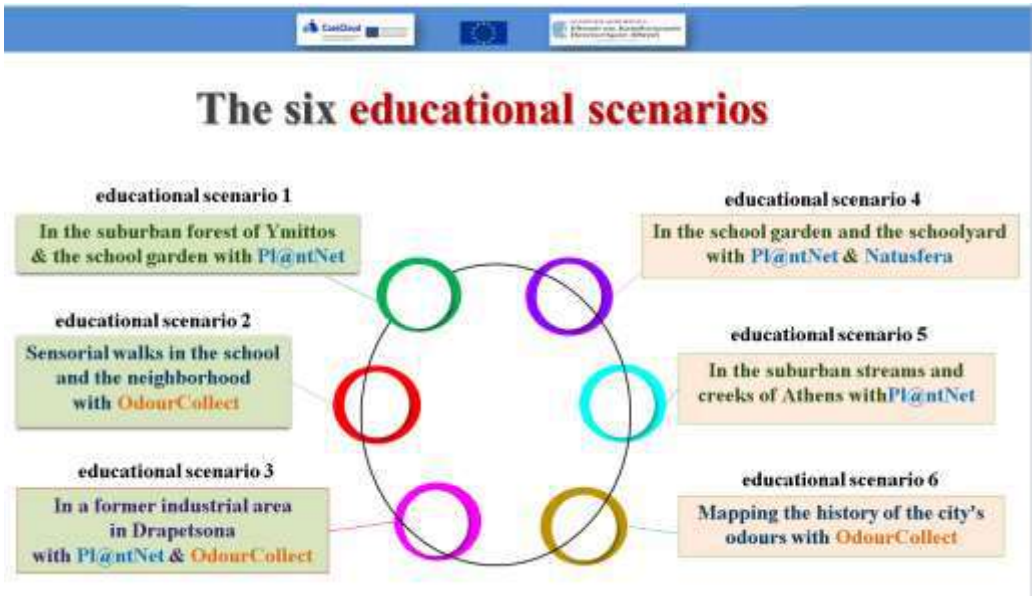

Figure 14: The six educational scenarios co-designed

Educational scenario 3 aims to integrate citizen science into EE/ESD with the use of **Pl@ntNet** and **OdourCollect**. It is addressed to students in the last years of **primary education** and invites them to engage in interdisciplinary activities including the creation of thematic maps, the construction of digital posters and cards and the formulation of their own proposal for the sustainable regeneration of the former industrial site of the Drapetsona Fertilizer and Chemical factory. The scenario attempts to link scientific observations and measurements made with Pl@ntNet for plant identification and with OdourCollect for recording odours and air pollution incidents, with local history and popular culture perspectives and to

integrate values and human rights concepts. The scenario can also be adapted and used as part of a cross-curricular school garden action plan or in the context of an intercultural education project. The use of tools from two different citizen observatories to 'map' the quality of the environment in an urban area of particular environmental concern emphasizes interdisciplinarity, builds digital competence and an orientation towards action. It also seeks to establish links with intercultural education through environmental knowledge, local traditions and popular culture.

Educational scenario 4 aims to connect citizen science with EE/ESD through the use of **Pl@ntNet** and **Natusfera**. Through an interdisciplinary approach it engages **secondary school** students, teachers, institutions and the academic community in various activities. It turns the school garden into a learning environment, raises awareness of climate change as a biodiversity problem, points to individual and social responsibility for addressing it, talks about the need to create a favourable microclimate in school settings, engages students with designing a green fence to absorb noise and chemical pollution, initiates a school-based composting project and raises awareness in the school and the local community. Through a combination of approaches and types of knowledge, this scenario aims to empower students to address current sustainability challenges through a scalable model of action that starts at their school. The school garden serves for experiential and collaborative learning based on the knowledge gained from using Pl@ntNet and Natusfera.

Educational scenario 5 looks at urban streams and creeks, which it describes as "isles of biodiversity" in the city. It focuses on the study of invasive/non-native species and the risks of ecosystemic changes. **High school students** take on the role of researcher, photograph the plant species prevalent in a local stream at the Chalandri Creek, identify them via **Pl@ntNet**, conduct a literature review search, and take a virtual tour of the area. In addition to raising awareness of the ecological value of streams, the scenario has a key goal to integrate citizen science into EE/ESD by promoting practices that generate environmental knowledge and promote scientific research. It includes a visit to the Environmental Education Centre in Argyroupoli, which runs a similar educational project on streams (the Pikrodaphne stream). The scenario combines inquiry and experiential learning, focuses on the study and promotion of urban biodiversity and emphasises the students' understanding and familiarisation with scientific research and the cultivation of their critical and inquiry thinking.

Finally, **educational scenario 6** attempts to link citizen science with EE/ESD and Oral History, based on the use of **OdourCollect** and the International Citizens Observatory for Odours. **Secondary school** students, teachers, the local community and other stakeholders are envisaged to engage in an interdisciplinary project to highlight the problem of odour pollution in contemporary cities through the collection of oral history narratives.

Besides, students construct a digital sensory map of place-based odours, which they enrich with local citizens' stories. They also develop a sense of their local community's odours and become motivated to take the role of active citizens and identify local environmental problems. The aim is that students develop a competence to combine different genres of knowledge, such as measurements of environmental quality (via OdourCollect) with intergenerational stories from their community (via oral history) and integrate them into a whole to contextualize and pursue local sustainable development.

In addition, the students will construct a digital sensory map of place-based odours, which they will enrich with stories collected from local citizens. They will also develop a sense of the odours in their local community and become motivated to take on the role of active citizens and identify local environmental problems. The aim is for students to develop the competence to combine different types of evidence, such as that from environmental quality measurements (through OdourCollect) with that from intergenerational stories collected from members of their community (through oral history) and integrate them into a whole to frame local sustainable development

4.4. The evaluation of the six educational scenarios

The evaluation of the educational scenarios was carried out on two levels:

(a) the *content* level of the educational scenario

(b) the *process* level of the co-design and co-production of the scenario

In relation to the **content-level evaluation**, **thematic analysis** was performed in the textual descriptions of the educational scenarios, looking for common and different themes. Thematic analysis moves beyond counting words and phrases and focuses on identifying and describing both explicit and implicit ideas within the data, that is 'themes'. Codes are then typically developed to represent the identified themes and applied or linked to raw data as summary markers for later analysis (Guest et al., 2012). Our analysis was based on the following **criteria**:

- **The scenario ID** (title, team members, keywords, core theme, central environmental/sustainability issue addressed, grade /class /age group, total duration/ number of phases, summary)
- **The link** between citizen science and EE/ESD
- Pedagogical use of the **citizen science digital tools** Pl@ntnet – OdourCollect
- **Pedagogical innovation** and **added value**
- **Strengths and weaknesses** of the ideas and the scenario's deployment
- **Activities** that can be adjusted and used in the Covid-19 period
- **Overall appraisal** of the scenario

The analysis was performed by the NKUA team. The participants/ educational designers were informed about the results of the analysis in the feedback the NKUA team gave to the groups during the final review meeting of the online training course. This feedback was provided **at two levels**: **i)** in the form of general comments on all scenarios, **ii)** as individualized comments on each scenario. A discussion was then held on the designers' overall experience of participating in the co-design process. Based on the feedback they received the groups were given the option to refine their scenarios. Moreover, some participants tweaked their scenarios after implementing them in real school conditions.

The **process-level evaluation** examined the co-design and co-production processes of the scenarios. The aim was to document the educational designers' experience and self-reflection during the entire process. This evidence was elicited in two ways:

i) through **group-reflection reports** the NKUA invited specific educational designers to produce 6 months after the completion of their scenario; and
ii) via **individual interviews** conducted with 13 course co-designers of educational scenarios between 5/1/2022 and 16/1/2022.

Narrative analysis as a qualitative research methodology (De Fina & Georgakopoulou, 2019; Clandinin, 2019) will be used to analyze the narrative accounts (both personal and collective) of educational designers about their experience of co-designing and co-producing their educational scenarios. At the time of drafting this report none of the data collected had been subjected to analysis.

In the following, we present the written reports of group reflections collected from the members of two "scenario groups": the group of **educational scenario 2** and the group of **educational scenario 6**.

GROUP REFLECTION on the co-design of educational scenario 2: "Scent of a school...scent of a neighborhood"

Having gained from my participation in the training course a fairly comprehensive understanding of what 'citizen science' is, our involvement in the co-design of the educational scenario was an opportunity to put this knowledge into practice.

When we came together for the first time as a group, we felt it was a real challenge, because we were asked to work with people we did not know very well and, in fact, from a distance. However, our initial embarrassment and any feelings of uncertainty receded almost immediately the first online contact, as soon as we became familiar with each other and quickly realized that we shared a lot, such as our passion for EE/ESD and the need to experiment with new ideas and practices, such as citizen science.

So, right from the start of this project our excitement was already high. However, we needed to get organised to meet our commitments. We agreed to follow a schedule and proceed step by step to accomplish one goal after the other. This, of course, was not an easy task, as we had to balance our personal and professional commitments to allow time for our group meetings at specific and regular time slots (twice a week).

However, where there's a will, there's a way. So, from the very beginning we formed the agenda of topics we wanted to deal with. We distributed responsibilities based on our personal interests, skills and strengths. We all contributed in our own way, each of us from their own perspective, each providing something the others had not thought of. And so there was a diversity of views and ideas. We spoke freely and frankly and exchanged views all the time in an attempt to produce the best possible outcome. This process was very creative, and we felt there was a sense of solidarity, mutual respect and understanding. Each complemented the other, we felt we belonged to a team with a common purpose and vision, and were content with what we had accomplished.

There were some moments of disagreement, which we tried to settle right away. It is important to have mutual understanding and support all the time, since at any moment something unexpected may happen to change the plans. It is also important to speak our minds bravely, without hesitating to admit weaknesses or any lack of knowledge out of fear of looking "less capable" in the eyes of others.

What is needed is a positive attitude, willingness to experiment and openness to new challenges. These are qualities that were present in our team and have been a driving force throughout our collaboration. The completion of the scenario made us feel proud of our work, but also somewhat uneasy at the end, as we realized that another productive collaboration was coming to an end. Luckily, reality proved us wrong, as our acquaintance and collaboration and sense of belonging to a community became the springboard for new collaborations thereafter.

GROUP REFLECTION on the co-design of educational scenario 6: "Our city's odours and their history. Mapping odours with OdourCollect"

Our group created the scenario "Our city's odours and their history" which involved the use of OdourCollect. Our meetings were held online via Webex. The first meeting was in October 2020 just to exchange our initial ideas. These ideas were sharpened in the following two meetings (November and December 2020), when we were handed thescenario template by the NKUA team to work on it. The deadline for submitting our scenario was end of December. However, we asked for an extension until the end of the first week of January, due to an already heavy workload on this period.

In our first meeting we identified the rationale, the method, and the tools we would use. We decided to combine citizen science with Oral History (OH) and integrate them both in an EE/ESD program. The techniques we had agreed on to use for teaching included brainstorming, the construction of a concept map, conducting interviews, a digital map of the city's odours and their history, the latter serving the dual purpose of a teaching method and as students' assignment.

The other two members of our group are environmental educators at the CEE of Elefsina, quite experienced in the production of educational material and the implementation of EE programs for schools visiting the Centre. I am a teacher, quite experienced in the implementation of school-based EE projects.

As we were working out the individual phases of the scenario, we wondered whether to use the OdourCollect app in each phase and how we could draw connections with the goals set out for each phase. We were also puzzled about whether both activities should make use of the OdourCollect app and to what extent OH and citizen science were sharing common things. How could we design the scenario so that students can learn and work with OH and citizen science in the same activity for combining different sources of data. Another concern was how to go about creating specific activity sheets for each of the two activities we had to design and

whether to include them in the Appendix or attach them as separate files. We finally decided to go for the latter.

In terms of how to best use the OdourCollect app we revisited the webinar's material and the teaching practices we had worked with (such as the "odour diaries" and the "school ambassadors"). We carefully studied the tools available in the OdourCollect platform. The D-NOSES platform gave us access to European laws and studies on odour pollution and the legal actions filed in connection with the Greek reality. We downloaded the app on our mobiles to identify diverse odours in our area, recorded the process, documented the terminology used and incorporated it into our scenario's activities, just like we did with the concept map. Having tested the app ourselves we could guide the students on how to use it as required in the second phase of the scenario.

Our cooperation was meaningful and intensive. We created a shared document which we gradually completed, corrected, and commented on. My cooperation with Nadia from the CEE of Elefsina was very dense. We communicated daily over the last two weeks before the deadline. Besides the online document we communicated by phone and videoconferencing. We are both very meticulous and perfectionists. Our collaboration was creative, with some tensions occurring sometimes but never reaching a tipping point. We especially focused on the final editing of the content and the consistent use of the terminology.

I collaborated once more with the same scenario group in February-March 2021, to transfer our Phase 1 in a distance learning program format (on the Webex platform), since we were in the period of Covid-19 lockdown. We decided to use more digital tools (such as the padlet and mentimeter), shared documents, breakout rooms and screen sharing. Then we split the tasks. The CEE educators and I who would implement the scenario with my students at the High School of Metamorphosi facilitated two of the three online meetings with a group of students. To coordinate the implementation, we held a preliminary online meeting with the second member of the teaching team. Then, for Phase 2, I guided my students remotely with presentations I had prepared and posted on the eClass platform. These presentations showed how to record odours with the OdourCollect app. I had also created a virtual Google Map, where each student would document locations where odours were detected and register them on route (e.g., home-school).

The third time our group collaborated was in May 2021 to present our scenario. This is when the NKUA team gave us feedback on our work and instructions how to refine our scenarios. At this stage, we added another activity in Phase 3, where students engaged in OH with old residents on the history of the city's odours. They added these stories to the digital sensory map they had created in Phase 2with scientists and experts on air pollution, to offer a scientific background to the oral accounts they had collected. Such an addition was an advantage for the presentation/dissemination of results (Phase 4). Finally, we incorporated the activity sheets into the scenario.

If I had to share with you a concluding comment, I would say that the collaborative effortswe offered to create this educational scenario were one of my longest, most immersive, lively and creative experiences.

4.5. Synthesis and a reflective comment on the six scenarios

Each of the six scenarios is unique in terms of the theme and scope employed and focuses on a different environmental issue. All scenarios have set clearly defined objectives and propose interesting and innovative methods of implementation. They also put forth a variety of approaches. They all share a number of common **quality features**, which are the following:

- They are accompanied by creative, realistic and pedagogically informed activities and employ a range of integrated and interdisciplinary approaches to learning;
- They promote active and experiential learning and seek to develop critical thinking, action skills and scientific/environmental literacies;
- They emphasize the use of digital tools and foster creative thinking;
- They aim to engage students with learning and improving their school and local communities and involve them in addressing issues of local concern.

Regarding the integration of citizen science in EE/ESD practice the six scenarios propose this to be accomplished at four levels, as illustrated in indicative activities of the scenarios:

a) At a **first** level, students are introduced to citizen science, with the aim to develop an understanding of the key concepts, to realize what is about and why we need citizen science, what are the citizen observatories and their platforms, and to get familiar with their usage.
b) At a **second** level, students observe, record and upload field-based data on the Cos4Cloud project's CO platforms, data on plant biodiversity or odours, which they collect at different areas and settings: their school, neighborhood, local park/ forest, a former industrial area, an urban creek, etc. They identify changes in the environments or problems that need to be addressed. This involvement brings up recollections and emotions which engage students more actively in the educational process.
c) The **third** level includes the development of specific scientific competences in students. The students act as research apprentices who participate in the design of field studies in the natural or social sciences. They also apply more than one scientific perspective and combine quantitative with qualitative data, i.e. by conducting interviews and literature reviews, administering questionnaires, comparing cases, etc.
d) The **fourth** level attempts to achieve a deeper integration of citizen science into the educational process. It aims at empowering the students to become active citizens and agents of change, get more actively involved in their local community, highlight real problems and seek for effective and more sustainable solutions. The students' engagement with their local environments is designed to take place in various ways: by creating biodiversity trails on their school grounds, asking the Mayor to listen to what they have to say, making concrete proposals how to redevelop their local environments, rolling up their sleeves and participating in planting activities, writing down the results of their study and presenting them in community awareness activities.

5. IMPLEMENTATION AND EVALUATION OF SCHOOL-BASED CITIZEN SCIENCE EDUCATIONAL PROJECTS AND ACTIVITIES

5.1. Introduction

As already outlined in Section 1, the main focus of **Sub-Task 6.4.2** is to develop and put into action a **General Design Model** of interconnected tasks and initiatives through which "a range of school-based CS designs making use of the CO platforms will be implemented and evaluated with the collaboration of local partners". In the previous sections we reported on the actions that enabled "**the set-up and evaluation of innovative school-based citizen-science activities making use of the Cos4Cloud project's technologies**". In this section we present the **implementation and evaluation of five Greek school case studies** that integrated two Cos4Cloud project's citizen observatories: **Pl@ntnet** and **OdourCollect**. We also describe the methodological **approach to evaluate** the learning potential and educational impact of these educational projects and present some preliminary results.

These 5 case studies were the follow-up to the online teacher training course and the creation of the educational scenarios. More particularly, **5 Greek teachers**, former participants in the online course and educational designers of the developed educational scenarios, carried out citizen science educational projects in their schools in collaboration with other colleagues and co-trainees. Although at the start of the project we had much higher expectations in terms of the number of case studies we could have achieved, given the upheaval caused by the pandemic in all areas of social life and activity, including school education, we are very pleased that these 5 Greek case studies were carried out. The operation of schools and all educational processes had to comply with public protection measures for a very long time and all teaching and learning shifted to a distance (online) level. A large number of extracurricular activities that were regularly organized every school year were suspended. Therefore, the implementation of these out-of-school curricula during the spring school term 2020-2021 was considered a great success and an indicator of the quality and effectiveness of our approach.

In the following sections we present the methodology used to evaluate the school case studies. We also report on the case studies and provide a preliminary analysis of the data collected from the narrative reports produced by the teachers.

5.2. Case study methodology for reporting and evaluating the case studies

The approach employed to collect, analyze and evaluate the school case studies is **case study methodology**. According to Merriam (1998) this is a qualitative research and evaluation paradigm that involves researchers in "an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit"

(p. xiii). The distinctive characteristics of this methodological approach are that it focuses on particular cases; it is mainly descriptive and aims to shed light on better understanding them.

Case study research is mostly or exclusively based on qualitative data and employs data collection techniques, such as interviews, observations, and document review. It draws data from multiple sources of evidence to capture the cases under study in their complexity.The analysis of case studies is a process of 'meaning-making' of the data collected that "involves consolidating, reducing, and interpreting what people have said and what the researcher has seen and read" (p. 178). Narrative analysis is among the methods usually employed for analysis and triangulation among the strategies to enhance internal validity. According to Merriam (1998), "the analysis becomes more intensive as the study progresses and once all data are collected" (p. 155). This is why a preliminary analysis of the data may lead to changes in the successive phases of the research.

In the Cos4Cloud project, case study methodology will be used for the evaluation of **school-based educational projects and activities**, which were designed and implemented to promote citizen science through EE with the use of Cos4Cloud CO platforms and tools. The focus of evaluation is on exploring specific facets of their implementation, and more particularly their (a) **learning potential** (b) **educational impact** in cultivating an environmentally and scientifically literate and active citizenry. Qualitative data will be drawn from more than one sources of evidence and collected via (a) **narrative accounts**, i.e, reflective reports on the implementation of the school educational projects and activities written by the teachers who carried them out, and (b) **interviews** with the teachers and other contributors to the implementation of the projects.

Narrative analysis will be conducted with a focus on illuminating the teachers' experience of implementing the educational scenarios (De Fina & Georgakopoulou, 2019; Clandinin, 2019). We are particularly interested in how teachers as former trainees and educational designers of the scenarios implemented have transferred their knowledge into practice; and how they assess the learning potential and educational impact of these projects. Findings will provide evidence-based input to European and national policy-makers and inform a new citizen science paradigm better aligned to the EOSC idea and implementation.

5.3. Qualitative data collection for the case studies

The collection of evaluative data will be based on the combination of two sources of qualitative data: a) teachers' narratives accounts; and b) interviews with them.

Narrative accounts of the implementation of the school-based educational projects in the form of reflective reports are the first source of qualitative evidence to be used. They will be collected from the teachers who designed and carried out the school projects. To facilitate the teachers' reflection and to structure case studies reporting and analysis the NKUA team designed **a case study report and evaluation form** which was sent to the teachers. The form asked them to briefly present the identity of their educational action. This was followed by a short description in which they had to explain the connection with the educational scenarios or activities created in the online course, the phases of project's development and the pedagogical use of the

platform/tools used. The teachers' personal reflections were then recorded, focusing on what they thought the students learned the added pedagogical value of using the CO platform/tools, the literacies developed and the wider educational impact. Finally, teachers were asked to state by responding to a short questionnaire what they thought the contribution of the Cos4Cloud project and the importance of citizen science for education was.

The analysis of the raw data collected from the five case studies reports led to the generation of **a profile for each case study**. In addition to the analysis of the reflective reports **individual interviews** were conducted with the five teachers between 5/1/2022 and 16/1/2022. Narrative analysis will be used to analyze the teachers' experience based on the interview data. At the time of drafting this report none of the interviews collected had been subjected to analysis.

5.4. Report and evaluation of the 5 case studies based on the teachers' narrative accounts

In this section we present the information collected through the reporting and evaluation forms completed by the teachers in an organized and structured manner and for each case study separately. More specifically, the data collected from the teachers' reflective narrative accounts were subjected to **a first-level analysis**. From this process, the important information for each educational project that conveys the perspective of the teacher in charge was selected. It is presented here in a structured, sufficiently informative and concise format.

A common way of presenting this information for each case was adopted, based on the elaboration and use of a generic template. This shared scheme was intended to make it easier to identify the points of interest for the evaluation and facilitate a second-level of analysis for each case thereafter as well as cross-case analysis.

The 5 case studies implemented and reported here are:

1. Exploring the school yard's flora with PI@ntnet
2. Greening the schoolyard with PI@ntnet as a compass
3. Using OdourCollect to create an olfactory map of the city
4. Walking with PI@ntnet in the archeological neighborhoods of Athens
5. Walking with GPS and identifying with PI@ntnet

Four of the case studies have taken place in **secondary** (2 in upper and 2 in lower secondary) schools and one in a **primary** school. Four of them have been based on the use of **PI@ntnet** and one on **OdourCollect**. Three case studies have used the **school** itself as the field of research, implementation and/or intervention, and more specifically the school garden, the school yard and/or the school neighborhood, while the other two were conducted in the **city** or at **sites** of special interest (e.g. archaeological sites). The use of the CO apps was primarily for identifying plants (i.e., in the schoolyard or an archaeological site) or to record odours (i.e., in an urban environment) and connect them with environmental problems. The case studies made use of 4 of the 6 **educational scenarios** (namely, 3, 4, 5 and 6)

The analysis of the teachers' reflective narrative accounts is still in progress and more detailed results and discussion will be presented in the final report.

School Case Study #1

Exploring the school yard's flora with Pl@ntnet

The case study in a nutshell

Project's title: "The magical world of plants – Changing the schoolyard with Pl@ntnet".

School: 2nd Junior High School of Melissia

Educational level/ Grade: Lower secondary school (Gymnasium)/ 9th grade

Students age level: 15

Participating students: 14

Teacher in charge: Mrs Christina Kalatha (Math educator)

Subjects: Biology, Geology [*plants (definition, parts, function), climate change, biodiversity, microclimate*], Language/Literature [*texts & myths, creative writing*], Maths [*counting plants, measuring quantities (temperature, distances etc.), distribution, graphical representations*], Social and Civic Education [*democratic participation, human rights, urbanization*], Computer-based learning [*internet search, collaborative documents*], Design [*garden architecture*], Visual arts [*plant-themed paintings, land art*], Linguistics [*Latin vocabulary of scientific terms, English*]

Duration: February - May 2021

Teaching hours: 18

Cos4Cloud CO: Pl@ntnet / Educational Scenario: 4

Implementation: the teacher's review

The educational project I carried out with 14 students of my school's *Environmental Education team* was based on the educational scenario I collaboratively designed with three more co-trainees in the context of the EEL/NKUA online training course. The scenario was titled "*The magical world of plants as a means of protecting life*" and aimed to engage students in exploring and studying the flora in their school garden at different seasons of the year. It was not limited there, however, but sought to empower students through scientific insights to develop their own plan for new plantings that would both enhance the beauty of the school grounds and also fit the Mediterranean climate of our country.

The project started in February 2021, while Greek schools were still in lockdown and all courses were held online. The students were initially informed about Pl@ntnet in the meetings I had with them on Webex. Using screen sharing on my computer, I presented the Pl@ntnet app and how to work with it, providing several examples of plant identifications based on photographs I had taken myself. I then showed my students how to install the Pl@ntnet app on their mobile phones. They then did some practice themselves by using the app on their daily walks to identify plants and trees in their domestic areas, thus providing new data to the Pl@ntnet platform and sharing information about the area's biodiversity. We then gathered together and I asked them for their feedback. All the students found the Pl@ntnet app an exciting and powerful tool to get information about the flora.

Upon the students' return back to school, I dedicated some teaching hours to work with them on the idea and practice of citizen science. I also made a more detailed presentation of the Pl@ntnet platform with a focus on the ways it can help users observe and record plants. I demonstrated that by clicking on the scientific term of a plant (in Latin) a world map shows up where one could get a picture of the areas the plant grows. I also explained how one can find more information about the flowering season of a plant, depending on whether it grows in the northern or southern hemisphere. The students were then divided into pairs and worked on a field study. They followed an organized environmental path in their schoolyard, exploring different parts of the yard, taking pictures of the plants with their mobile phones and identifying them with the Pl@ntNet app. They made a record of all plants along the path and categorized their collected data on a database table.On this occasion, I used this as an opportunity of teach about the math concept of distribution and the construction of curves to represent a plant's spatial span across the globe and the seasonal changes in its cycles of life during the year.

The students were then entered into a discussion about the validity of their identifications.

They looked on the World Wide Web to find supplementary sources to check the results for identifying each plant species they recorded through the Pl@ntnet platform. They thus realized that, first, this is part of a rigorous and collectively built and shared scientific procedure which Pl@ntnet platform enabled them to have access to depending on the quality of the photographs uploaded to it, the correct angle of the captured photos and the density of the photo posts and related annotations by large numbers of the platform's community.

The project, still in progress, continues in the current school year 2021-2022 with new goals and activities.

Evaluation: the teacher's self-reflection

The three most important learning gains for my students participating in this educational project are…

1) the development of new digital skills through their engagement with challenging digital tools, 2) the experience they gained by observing and recording the urban nature in their everyday environments, and 3) the nurturing of a sense of place and belonging, after realizing that their life is strongly connected to their city's natural environment and after recognizing the value of nature in urban spaces.

In terms of environmental literacy, my students were enabled to…

realize that flora is linked to and dependent on the environmental conditions of an urban area and affected by seasonal and climate changes. They also realised that an area's flora and biodiversity can also affect the micro-climatic conditions of the place.

In terms of scientific literacy, my students were enabled to…

learn more about the plants species in their living area and their schoolyard. They were also trained how to identify them and name them both in Greek and in their formal scientific term in Latin. Finally, the students realized that scientific knowledge is based on an educated way of thinking that makes use of a sequence of standard scientific processes and criteria and that technology may become a powerful tool towards these goals.

In terms of citizenship literacy, my students were enabled to…

develop an active and participatory stance towards recording, studying and improving urban nature and contributing to the greening of their school environments. This a starting point for shaping an identity of responsible citizenship towards local sustainability.

The added pedagogical value brought in by the use of the CO platform/app was…

that the students benefited from using a new digital tool for doing science and learning about nature in their school education. Science became a fun topic to address in outdoor classroom activities, without losing their focus on the need to ensure rigorous scientific

procedures should be and how technology may add to it.

Implementing this educational project was a teaching challenge for me because…

It triggered me to apply the knowledge I gained from the EEL/NKUA online training course in my school practice. It also gave me the incentives and challenged me to work with my students with fresh ideas and new tools based on digital technologies.

Besides my students learning, the project's impact on the school community…

On the occasion of this educational activity I carried out, other teachers in my school learned about Citizen Science and the Pl@ntNet platform and they might use it in their school practice.

The project's impact on the local community…

The students have shared with their family and friends the knowledge and experience with the project in general and especially with Pl@ntNet platform. Therefore, these new ideas and tools are now spreading in the community.

The project's impact on promoting sustainability…

I could consider such educational activities essential in promoting sustainability, because raising awareness on issues of biodiversity in the urban environment is a significant challenge in our days.

Final notes: the teacher's appraisal

Support for implementing this school educational project came from…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
a. Participation in the **online training course** run by NKUA helped me implement this educational project.	**X**				
b. Participation in the development of an **educational scenario** helped me implement this educational project.	**X**				

Regarding the integration on Citizen Science and Citizen Observatories in school education, I believe that…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*

c. Having an educational scenario is helpful for a teacher in order to implement relevant educational activities.	**X**				
d. Citizen Science fits in and can be integrated in the school curriculum.	**X**				
e. Citizen Science fits in and can be combined with Environmental Education for the benefit of both.	**X**				
f. The introduction to the various Citizen Observatories and the services they offer as well as their pedagogical use needs to be supported through more training courses for teachers.	**X**				

Intention for future implementation

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
g. I am open/ positively inclined to implement educational activities that make good use of Citizen Science and the Citizen Observatories in the future.	**X**				

School Case Study #2

Greening the schoolyard with Pl@ntNet

The case study in a nutshell

Project's title: "The magical world of plants as a means of protecting life. In the schoolyard with Pl@ntNet".

School: 7thSenior High School of Piraeus

Educational level/Grade: Lyceum (Upper Secondary Education)/14th Grade

Students age level: 17

Participating students: 10

Teachers in charge: Mrs Smaragda Kollia (Agronomist)

Subjects: Biology, Geology, Computer science, Design arts, Physical education

Duration: December 2020 - April 2021

Teaching hours: 30

Cos4Cloud CO: Pl@ntNet/ Educational Scenario: 4

Implementation: the teacher's review

In the tiny courtyard of our school, which rested uncultivated for years and suffocating in the urban environment, where one could find only small flowerbeds, we had a great challenge, both environmental and learning, to face: how to engage students in "greening" our daily school life. I participated in the EEL/NKUA online training course and this was what we had in mind when my team decided on the focus of our educational scenario we called "*The magical world of plants as a means of protecting life*".

I used this educational scenario as a guide to carry out this school project with my students. The main objective was to create a new 'learning space' for the students by actively involving them in upgrading our schoolyard. So,

with the Pl@ntNet application on their mobiles, the students first identified all existing plants in the schoolyard. They recorded them and then searched for more information about them. They considered each of them separately by applying both scientific and environmental criteria. They also checked whether these plants are suitable for the climate conditions of our area. Using the same criteria, the students looked for new and more suitable plants for the schoolyard, while they also addressed the issue of climate change.

Then, based on their search and study, the needs of the school community and the environmental and climate conditions of the area, the students designed their schoolyard with their suggested new plantings. In this task my role as agronomist was to guide and advise them on the different choices they considered.

And we did it! Following these steps and with much personal hard work we managed to "green" the schoolyard with a variety of plants: flowering plants that bloom and give off lovely smells (i.e., we created a green fence by a climbing honeysuckle), seasonal vegetable gardens (such as a small vegetable garden to grow lettuces and onions in winter and tomatoes, eggplants, zucchinis, okras, peppers, and watermelons in summer), a grove of trees (with one mandarin, one lemon and one orange tree and two lilac trees), a small garden with aromatic plants (such as lavender, thyme and rosemary), another one with some bulbous plants (freesias and crocus), as well as plants such as citronella, a piece of mesquite for ground cover, and a rose bush. These came to join the Mediterranean redbud, the flame trees, a moon trefoil tree, and the oleanders.

Our educational project didn't come to an end and will go on next year. In the long run we hope to empower our students how to design and build a green space from scratch, not only a school garden but any other open space in their neighborhoods or local communities. Our focus is on local sustainability and we aim to contribute to create 'greener' cities. We would like to see our students working to the direction of improving not only the aesthetic part of their places, but also to take action towards more sustainable solutions in favour of mitigating and adapting to climate change.

Evaluation: the teacher's self-reflection

The three most important learning gains for my students participating in this educational project are…

(a) plants are important elements in our lives in modern cities, (b) not any plants are suitable for any place, (c) climate change has an impact on the plants that grow in our living places and vice versa.

In terms of environmental literacy, my students were enabled to…

develop understandings on how we, the humans, and nature are on a symbiotic relationship and that we need adapt to climate change even in our everyday life and choices, such as when it comes to select the plants to grow in our schoolyard or even in the balcony of our

home.

In terms of scientific literacy, my students were enabled to…

to identify plant species as living organisms and ecological factors; and to understand how they affect and are affected by the environmental conditions around them.

In terms of citizenship literacy, my students were enabled to…

come across new ways of participating as environmental stewards to investigate and advance the environmental quality of urban spaces in their school and local communities. They were also enabled to recognize the importance of working towards sustainability by promoting a harmonious coexistence with nature and by seeking ways to successfully adapt to climate change.

The added pedagogical value brought in by the use of the CO platform/app was…

that the students had the opportunity to identify any plant they came across using only their mobile phones. The app also provided them with interesting and useful information and helped them make their planting choices for their area more easily.

Implementing this educational project was a teaching challenge for me because…

The school is located in an urban area with low levels of vegetation and thus they had no many plants to identify.

Besides my students' learning, the project's impact on the school community…

is that, despite the difficulties, we managed to turn our schoolyard into a green urban space spot by following on an integrated scientific and environmental approach.

The project's impact on the local community…

starts from the fact that our school approach and action became an example for the community. Moreover, our new school grounds are there, greener and welcoming and our plans are now to change the whole neighborhood by turning it into 'a green breath of life'.

The project's impact on promoting sustainability…

it was the experience we gained by working towards sustainability in our city, all the new sustainable practices we adopted (such as composting) and the fact that we recognized the value of urban biodiversity and the importance of sustainable coexistence to deal with the climate change challenges.

Final notes: the teacher's appraisal

Support for implementing this school educational project came from…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*

a. Participation in the **online training course** run by NKUA helped me implement this educational project.	**X**				
b. Participation in the development of an **educational scenario** helped me implement this educational project.	**X**				

Regarding the integration on Citizen Science and Citizen Observatories in school education, I believe that…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
c. Having an educational scenario is helpful for a teacher in order to implement relevant educational activities.	**X**				
d. Citizen Science fits in and can be integrated in the school curriculum.	**X**				
e. Citizen Science fits in and can be combined with Environmental Education for the benefit of both.	**X**				
f. The introduction to the various Citizen Observatories and the services they offer as well as their pedagogical use needs to be supported through more training courses for teachers.	**X**				

Intention for future implementation

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
g. I am open/ positively inclined to implement educational activities that make good use of Citizen Science and the Citizen Observatories in the future.	**X**				

School Case Study #3

Using OdourCollect to create an olfactory map of the city

The case study in a nutshell

Title: "The odours of our city and their stories - Mapping environmental odours with OdourCollect"

School: 1st General Lyceum of Metamorphosis

Educational level/Grade: Lyceum (Upper Secondary Education School) /11th grade

Students age level: 16-17

Participating students: 21

Teachers in charge: Anna Trigatzi (Teacher of Greek Language & Literature) – Alexandra Ilia (School's Headmaster and Teacher of Biology)

Subjects: Philosophy ("Humans & Natural Environment") – Biology ("The ecosystem")

Duration: March - May 2021

Teaching hours: 8

Cos4Cloud CC: OdourCollect / Educational Scenario: 6

Implementation: the teacher's review

During the school year 2020-2021, the educational activities we implemented in our school are linked to the scenario we co-designed with other fellow trainees in the context of the EEL/NKUA online training course. What we actually did was to put into action **Phase 1** of our scenario and **Activities 1**and **3** of **Phase 2**.In particular, we adapted Phase 1 so as to be carried out entirely through distance education, because at the time the schools were on lockdown due to the Covid-19 pandemic.

More precisely, in our first meeting with the students (2 teaching hours), we run **Activity 1**(of **Phase 1)**, which aims to stimulate the senses, especially the sense of smell. We used **Padlet** and **Google docs**. The students took a photo of the view from the window or balcony of their house and posted it on the Padlet with comments on how they felt about the smells emitted.

Activity 2 (of **Phase 1)** was about how to connect bad odours with environmental problems followed by an introduction to citizen science, and **Activity 3 (**of **Phase 1)** included a presentation of the platform of the International Odour Observatory. We implement them both during our second and third meetings (2 and 1 teaching hour respectively) with the students. We also invited our co-designers of the scenario, the environmental educators of the Elefsina Centre for Environmental Education (CEE). In Activity 2 we worked with: **(a)** worksheets that included **brainstorming** about the smells of the city, the results of which were presented as a word cloud map, **(b)** a **conceptual map** about smells, their causes and consequences as well as the emotions they evoke, and **(c)pictures of the city**, which the students -divided into breakout rooms in 'Webex' distance learning platform- had to associate with odours, to characterize and evaluate according to specific criteria and to present to the plenary session.

We talked about the city of Elefsina and the environmental problems it faces that are reflected in bad odours. Playing the song "The nightmare of Persephone" by the Greek well-known composer Manos Hadjidakis we displayed in the screen typical photos of the city. We finally used (mentimeter) to create a short questionnaire and asked students to share their views and reactions as a feedback and evaluate the content knowledge and awareness they developed. The introduction to the concept of citizen science and the presentation of OdourCollect (Activity 3) was done by screen sharing the OdourCollect platform's webpage during our third group meeting.

The **Activities 1** and **3** of **Phase 2** were assigned to the students through the e-Class. However, instructions on how to download and use the OdourCollect app to register uncommon odours in their environments were given when we all met from close, after the schools' re-opening. A smaller group of students created with the use of Google Maps an environmental path that went from home to school, based on which they recorded the identified odours in the OdourCollect app. Finally, in **Activity 3** the students posted on the digital map they had created a photo of the spot where they registered each odour in the OdourCollect app and accompanied with a comment on the type of odour.

Apart from the necessary adaptations we brought about to turn the implementation of the activities to run online, we followed entirely the scenario we created. The two school teachers worked together with the environmental educators from Elefsina CEE, each of us taking the responsibility for certain activities. **Activities (1, 2, 3)** of **Phase 1** aimed to get students to reflect on the connection between odours and environmental problems and to familiarize them with the terms, concepts and rationale of the OdourCollect platform. In **Phase 2**, where we have mainly integrated the use of OdourCollect app, the students who implemented **Activities 1 & 3**designed the environmental path, walked around the siteto inspect the odours and then posted the recorded incidents on the digital map, either each one individually or in pairs. The project as implemented was presented at the annual school meeting for environmental education organized by the 2ndAthens Education Directorate.

Evaluation: the teacher's self-refection

The three most important learning gains for my students participating in this educational project are…

(a) the awaken of their senses by applying a more-than-cognitive approach to get to know their neighborhood,

(b) the correlation of odours with environmental quality and

(c) the use of digital tools as an alternative way of learning about environmental issues in the context of distance education.

In terms of environmental literacy, my students were enabled to…

connect odours with environmental quality.

In terms of scientific literacy, my students were enabled to…

get in touch with scientific research conducted worldwide and in Greece (the D-Noses project).

In terms of citizenship literacy, my students were enabled to…

develop new content knowledge and skills (digital and other) to become more actively engaged in mapping and claiming environmental quality in their local community.

The added pedagogical value brought in by the use of the CO platform/app was…

that the students became aware of how odours can be an indicator of environmental quality. They also realized how helpful is a comprehensive and descriptive visualization of various such incidents in the region, such as on an international map of odours.

Implementing this educational project was a teaching challenge for me because…

I had to link the theory of citizen science and COs with the practice of environmental education in an imaginative and well-structured educational scenario. The fact that I had to implement the activity through distance learning was a big challenge too.

Besides my students' learning, the project's impact on the school community …

wasthat citizen science as a concept and practice was introduced to the school community and that our school cooperated with a European project that promotes the coupling of educational practice with educational research and innovation.

The project's impact on the local community….

is aimed to be, when the project will be completed, the creation of an odour map of the city. This map will be an important achievement as it will depict the links between environmental issues and the local oral history.

The project's impact on promoting sustainability…

is related to the fact that the educational project promotes a holistic view of the environment and addresses sustainability issues. By making use of an interdisciplinary approach the project promotes a new understanding of environmental quality and empowers students to explore and claim the conditions that lead to it in their community.

Final notes: the teacher's appraisal

Support for implementing this school educational project came from…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
a. Participation in the	**X**				

online training course run by NKUA helped me implement this educational project.					
b. Participation in the development of an **educational scenario** helped me implement this educational project.	**X**				

Regarding the integration on Citizen Science and Citizen Observatories in school education, I believe that…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
c. Having an educational scenario is helpful for a teacher in order to implement relevant educational activities.	**X**				
d. Citizen Science fits in and can be integrated in the school curriculum.	**X**				
e. Citizen Science fits in and can be combined with Environmental Education for the benefit of both.	**X**				
f. The introduction to the various Citizen Observatories and the services they offer as well as their pedagogical use		**X**			

needs to be supported through more training courses for teachers.					

Intention for future implementation

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
g. I am open/ positively inclined to implement educational activities that make good use of Citizen Science and the Citizen Observatories in the future.		**X**			

School Case Study #4
Walking with Pl@ntnet
in the archaeological neighbourhoods of Athens

The case study in a nutshell

Title: «Plants in Athens archaeological sites: the Hill of Nymphs, Ancient Agora, Keramikos"

School: 3rd Primary School of Korydallos

Educational level/Grade: Primary Education/ 6th grade

Students age level: 12

Participating students: 21

Teacher in charge: Christos Godevas (primary education teacher)

Subjects: History, Geography, Physics

Duration: March – June 2021

Teaching hours: 10

Cos4Cloud CC: Pl@ntNet / Educational Scenario: 3

Implementation: the teacher's review

I am a member of the team who created the educational scenario "*Using Pl@ntNet & OdourCollect to explore a former industrial area in the city of Drapetsona*" in the context of the NKUA's online training course. In the previous school year, we had collaborated with my co-designers from the Environmental Education Centre of Drapetsona in another project, called "Adopt a Ship", to design activities exploring the coastal area of the port of Piraeus , which I carried out with my students. In our current collaboration within the Cos4Cloud project the context of study was a former industrial space, the Drapetsona's old Fertilizer Factory, which has been converted into a multi-purpose industrial heritage site.

However, due to the Covid-19 pandemic and the difficult situation we experienced throughout the country and particularly in schools, we did not have the opportunity to

implement the scenario the way it was initially conceived, except for a small part of it which was planned to be carried out in specific archaeological sites. So, what I actually did is an adaptation and modification of the scenario to meet the current conditions.

The educational project was implemented in two phases:

The first phase took place from March to May 2021 and was conducted online, due to measures imposed to all Greek schools for protection against Covid-19. All the meetings with students were held online (in Webex). In our first meeting I introduced the Pl@ntnet Citizen Observatory to my students. I then explained and gave them instructions on how to use the mobile app and encouraged them to familiarize themselves with it in their free time by walking around and taking pictures of different plants in the school and their neighborhood.

The second phase took place in June 2021. Back to school and back to normal teaching conditions, the students had the opportunity to meet in person, work together. I organized a series of open air walks with my students in three very prominent archaeological sites of Athens, the Hill of Nymphs, the Ancient Agora and Kerameikos. In these visits I explained my students that the task was to record and identify all the plants growing in each of these archaeological sites with the use of Pl@ntnet app. The students strolled through the ancient sites, following an environmental trail and they spotted various types of vegetation present there, took photos and identified the plants using Pl@ntnet. Among the various plants they recorded and identified there were: the laurel, the oleander, the olive tree, the ivy tree, the mulberry, the carob, the boxwood, etc. All of them were classified in a table along with their observations.

Evaluation: the teacher's self-refection

The three most important learning gains for my students participating in this educational project are…

(a) the experience of outdoor environmental learning in the field

(b) their participation in processes of plant identification as a way to contribute to citizen science and environmental education practice, but also as

(c) an active participation in the community.

In terms of environmental literacy, my students were enabled to…

acquire new content knowledge about the plants and the role of urban green in citizens' lives.

In terms of scientific literacy, my students were enabled to…

make new observations and to collect and record data with the use of digital tools as an aid to draw conclusions more accurately.

In terms of citizenship literacy, my students were enabled to…

realize that scientific research and data collection procedures area powerful tool to assist people get to know their environment better.

The added pedagogical value brought in by the use of the CO platform/app was

that it offered an accurate way to identify plants species and helped the students realise that Citizen Observatories have a lot to do with them personally.

Implementing this educational project was a teaching challenge for me because…

I tried to familiarise my students with how to learn while actively involved in scientific research processes.

Besides my students' learning, the project's impact on the school community …

had to do with the students investigating the plants that make up a green area in their school, a project that influenced other students too.

The project's impact on the local community….

has to do with the realization that when we learn about biodiversity in the city and take action to preserve it, we understand that it's something that every citizen should be concerned about.

The project's impact on promoting sustainability…

is something obvious that both as an action and an educational process goes hand in hand with the promotion of sustainability, trying to reduce the students' ecological footprint as much as possible.

Final notes: the teacher's appraisal

Support for implementing this school educational project came from…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
a. Participation in the **online training course** run by NKUA helped me implement this educational project.	**X**				
b. Participation in the development of an **educational scenario** helped me	**X**				

implement this educational project.					

Regarding the integration on Citizen Science and Citizen Observatories in school education, I believe that…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
c. Having an educational scenario is helpful for a teacher in order to implement relevant educational activities.	**X**				
d. Citizen Science fits in and can be integrated in the school curriculum.	**X**				
e. Citizen Science fits in and can be combined with Environmental Education for the benefit of both.	**X**				
f. The introduction to the various Citizen Observatories and the services they offer as well as their pedagogical use needs to be supported through more training courses for teachers.	**X**				

Intention for future implementation

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
g. I am open/ positively inclined to implement educational activities that make good use of Citizen Science and the Citizen Observatories in the future.	**X**				

School Case Study #5

Walking with GPS and identifying with Pl@ntNet

The case study in a nutshell

Title: «I walk with GPS and identify with Pl@ntNet»

School: 8th Junior High School of Halandri

Educational level/Grade: Gymnasium (Lower secondary school)/ 8th grade

Students age level: 13 -14

Participating students: 65

Teachers in charge: Fotis Danaskos (Geologist)

Subjects: Geology and Geography

Duration: April - May 2021

Teaching hours: 12

Cos4Cloud CC: Pl@ntNet / Educational Scenario: 5

Implementation: the teacher's review

The educational activities we implemented in the school are linked to the educational scenario that we designed with my team in the online training course organized by NKUA in the framework of the Cos4Cloud project. Due to the special circumstances that had been created by the Covid-19 pandemic at the time, my team converted a large part of Phase 1 and Phase 2 so that it could be implemented remotely. After returning to school in May 2021, we had the opportunity to conduct part of Phases 1 and 2 via face-to-face meetings. Unfortunately, we were unable to carry out Phase 3, as the timeline was very tight after the schools reopened.

I used activity sheets with instructions how to be used by the students, which I created having based on examples I got from my colleagues at CEE Argyroupolis. The students, first via WEBEX and then after they got back to school, they used the Pl@ntNet platform

and the Google Earth apps combined.

They initially installed both applications on their smartphones, in order to learn how to use them at home and in their garden. Then, they worked in groups with Pl@ntNet to identify the flora in our schoolyard and they used Google Earth to track their exact location. They then entered the details about each plant and its exact location on the Worksheets using the built-in GPS and the Google Earth app on their smartphones.

Later, when all the students met in class, they discussed about the results of their work, how they had had used the tools as well as what particular skills they had acquired. They expressed their satisfaction that they had learned to search for, record and identify different plant species and determine their geographical location accurately.

Evaluation: the teacher's self-refection

The three most important learning gains for my students participating in this educational project are…

(a) apart from their general use, these specific applications on smartphones also serve important purposes, such as they can be used in science,

(b) that they got to know about the Citizen Observatories and became familiar with Pl@ntnet un particular, (c) the contact they had with the flora of the area where they live.

In terms of environmental literacy, my students were enabled to…

develop knowledge about the flora of a certain area and the various species of flora that grow there.

In terms of scientific literacy, my students were enabled to…

realize that they can seek scientific knowledge using digital applications.

In terms of citizenship literacy, my students were enabled to…

develop knowledge that will enable them to understand that they can use it when they need to act for the benefit of their community.

The added pedagogical value brought in by the use of the CO platform/app was…

that the knowledge of how the Pl@ntNet platform functions combined with that of the Google Earth application, serves as tools for students to explore and learn.

Implementing this educational project was a teaching challenge for me because…

I succeeded in giving my students the opportunity to use two digital applications that are mostly used by adults in the context of citizen science.

Besides my students' learning, the project's impact on the school community …

was important because it was the first time that the students had the opportunity to get to know and use two quite advanced digital applications in the school context and combine them with scientific thinking processes.

The project's impact on the local community….

It is based on the fact that students' knowledge of the flora and species that thrive in their area, both endemic and non-endemic, is expected to reflect a better connection with their environment in the foreseeable future.

The project's impact on promoting sustainability…

is somehow self-evident, since both as an action and as an educational process, this project moves in the direction of sustainability. The fact that the students have become familiar with the various species of flora in their area is a starting point for developing an informed interest in it, its protection, and local sustainable development.

Final notes: the teacher's appraisal

Support for implementing this school educational project came from…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
a. Participation in the **online training course** run by NKUA helped me implement this educational project.	**X**				
b. Participation in the development of an **educational scenario** helped me implement this educational project.		**X**			

Regarding the integration on Citizen Science and Citizen Observatories in school education, I believe that…

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
c. Having an educational scenario is helpful for a teacher in order to implement relevant educational activities.	**X**				
d. Citizen Science fits in and can be integrated in the	**X**				

school curriculum.					
e. Citizen Science fits in and can be combined with Environmental Education for the benefit of both.	**X**				
f. The introduction to the various Citizen Observatories and the services they offer as well as their pedagogical use needs to be supported through more training courses for teachers.	**X**				

Intention for future implementation

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	*N/A*
g. I am open/ positively inclined to implement educational activities that make good use of Citizen Science and the Citizen Observatories in the future.		**X**			

REFERENCES

Anderson, T. (2013). Open access scholarly publications as OER. *The International Review of Research in Open and Distributed Learning, 14*(2), 81. doi: 10.19173/irrodl.v14i2.1531.

Blaney, R. J. P., Jones, G., Philippe, A., & Pocock, M. (2016). Citizen science and environmental monitoring: towards a methodology for evaluating opportunities, costs and benefits. *Final Report on behalf of UKEOF*.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience*, *59*(11), 977-984.

Bonney, R., Phillips, T. B., Ballard, H. L., and Enck, J. W. (2016). Can citizen science enhance public understanding of science? *Public Understanding of Scince, 25*, 2-16. doi: 10.1177/0963662515607406

Bonney, R., Phillips, T. B., Enck, J., Shirk, J., & Trautmann, N. (2015). *Citizen Science and Youth Education.* Commissioned by the National Research Council Committee on Out-of-School Time STEM Learning. Washington, DC: National Research Council. URL: http://sites.nationalacademies. org/cs/groups/dbassesite/documents/webpage/dbasse_089993. pdf

Bossu, C., & Heck, T. (2020). Engaging with Open Science in Learning and Teaching. *Education for Information*, *36*(3), 211-225.

Bray, C. (2008). Program evaluation of the sustainability of teaching methods. *Environmental Education Research*, *14*(6), 655-666.

Breiting, S., & Mogensen, F. (1999). Action competence and environmental education. *Cambridge Journal of Education*, *29*(3), 349-353.

Brody, M., & Storksdieck, M. (2013). Evaluation and Analysis of Environmental Education Programs. Materials, and Technologies and the Assessment of Learners and Learning. In: Stevenson, R.B., M. Brody, J. Dillon, and A. E. J. Wals, eds. 2013. *International Handbook on Research on Environmental Education*, (pp. 285-288). New York: Routledge.

Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education*, *27*(9), 1099-1121.

Carleton-Hug, A., & Hug, J. W. (2010). Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program planning*, *33*(2), 159-164.

Clandinin, D. J. (2019). Narrative and story in teacher education. In *Journeys in Narrative Inquiry* (pp. 91-102). Routledge.

Crohn, K., & Birnbaum, M. (2010). Environmental education evaluation: Time to reflect, time for change. *Evaluation and Program Planning*, 33(2), 155-158.

Daele A., Brassard C., Esnault L., Donoghue M., Uytterbrouk E., Zeiliger R. (2002). *Conception, mise en œuvre, analyse et évaluation des scenarios pédagogiques recourant à l' sage des TIC*. Rapport du Projet Recre@supWP2FUNDP.

De Fina, A., & Georgakopoulou, A. (2019). *The handbook of narrative analysis*.John Wiley & Sons.

Dickinson, J. L., Shirk, J., Bonter, D., Bonney, R., Crain, R. L., Martin, J., ... & Purcell, K. (2012). The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment*, *10*(6), 291-297.

Edwards, R., Kirn, S., Hillman, T., Kloetzer, L., Mathieson, K., McDonnell, D., & Phillips, T. (2018). Learning and developing science capital through citizen science. In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds), *Citizen science: innovation in open science, society and policy* (pp. 381-390).UCL Press.

European Commission. (2016). Open Innovation, Open Science, Open to the World – A vision for Europe. Luxembourg: Publications Office of the European Union

European Commission (2017). *Horizon 2020 Work Programme 2018–2020. Science with and for Society*. Available online at: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society (accessed January 2022).

European Commission (2019). Open science – The eight ambitions of Open Science. European Commission Factsheet.

Garde-Hansen, J., & Calvert, B. (2016). Developing a research culture in the undergraduate curriculum. *Active Learning in Higher Education,* 8(2), 105–116. doi: 10.1177/1469787407077984.

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

Guest, G., MacQueen, K. M., & Namey, E. E. (2011). *Applied Thematic Analysis*.Sage Publications.https://dx.doi.org/10.4135/9781483384436

Harlin, J., Kloetzer, L., Patton, D., & Leonhard, C. (2018).Turning students into citizen scientists.In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds), *Citizen science: innovation in open science, society and policy* (pp. 410-428).UCL Press.

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (2018). *Citizen science: innovation in open science, society and policy*. UCL Press. URL: https://discovery.ucl.ac.uk/id/eprint/10058422/1/Citizen-Science.pdf

Jenks, B., Vaughan, P. W., & Butler, P. J. (2010). The evolution of Rare Pride: Using evaluation to drive adaptive management in a biodiversity conservation organization. *Evaluation and Program Planning*, *33*(2), 186-190.

Jensen, B. B., & Schnack, K. (1997).The action competence approach in environmental education. *Environmental Education Research*, *3*(2), 163-178.

Jordan, R. C., Gray, S. A., Howe, D. V., Brooks, W. R., & Ehrenfeld, J. G. (2011). Knowledge gain and behavioral change in citizen-science programs. *Conservation Biology*, *25*(6), 1148-1154.

Ketlhoilwe, M. J. (2006). *Course evaluation in Adult Education Programmes.In Support of environmental and sustainable educational processes.*SADC Regional Environmental Education Programme Course Developers' Toolkit.Howick.Share-Net.

Khaldi M., Barhone, J., Erradi, M., Khaldi, M. (2020).The educational scenario architecture of a learning situation. *Global Journal of Engineering and Technology Advances*, *3*(1), 027-040.

Kieslinger, B., Schäfer, T., Heigl, F., Dörler, D., Richter, A., & Bonn, A. (2018). Evaluating citizen science-towards an open framework. In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds), *Citizen science: innovation in open science, society and policy* (pp. 81-95). UCL Press.

Makuch, K., & Aczel, M. (2018).Children and citizen science.In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds), *Citizen science: innovation in open science, society and policy* (pp. 391-409).UCL Press.

Mendez, E., Lawrence, R., MacCallum, C.J., & Moar, E. (2020). *Progress on Open Science: Towards a Shared Research Knowledge System: Final Report of the Open Science Policy Platform*. doi: 10.2777/00139.

Merriam, S. B. (1998). Qualitative research and case study applications in education. San Francisco, CA: Jossey-Bass.

Monroe, M.C., & Jie Li, C., (2013). Evaluation Techniques that Improve Programs. In: M.C. Monroe &M.E. Krasny (eds.). *Across the Spectrum.Resources for Environmental Educators,* (pp.113-125).North American Association for Environmental Education (NAAEE).

Pernin, J. P., & Lejeune, A. (2004).Dispositifs d'apprentissage instrumentés par les technologies: vers une ingénierie centre sur les scénarios. In *Technologies de l'Information et de la Connaissance dans l' Enseignement Supérieur et de l' Industrie* (pp. 407-414).Université de Technologie de Compiègne.

Phillips, T., Ferguson, M., Minarchek, M., Porticella, N., & Bonney, R. (2014).*Evaluating learning outcomes from citizen science*. Cornell Lab of Ornithology, Ithaca.

Rincon-Gallardo, S. & Fullan, M. (2016).Essential Features of Effective Networks in Education.*Journal of Professional Capital and Community, 1*, 5-22. DOI: 10.1108/JPCC-09-2015-0007

Roche, J., Bell, L., Galvão, C., Golumbic, Y. N., Kloetzer, L., Knoben, N., ...& Winter, S. (2020). Citizen science, education, and learning: challenges and opportunities. *Frontiers in Sociology*, *5*, 110.https://doi.org/10.3389/fsoc.2020.613814

Ross-Hellauer, T. (2017). What is open peer review? A systematic review.*F1000Research, 6*, 588. doi: 10.12688/f1000research.11369.2.

Russo, V., & Olvitt, L. (2006).*Course Materials Development for Adult Learning.In support of environmental educationprocesses*.SADC Regional Environmental Education Programme Course Developers' Toolkit. Howick, ShareNet. Retrieved 11/05/2014, from: www.sadc-reep.org.za/uploads/documents/materials/Source_Book_3_Reduced.pdf

Saunders, M. E., Roger, E., Geary, W. L., Meredith, F., Welbourne, D. J., Bako, A., ...& Moles, A. T. (2018). Citizen science in schools: Engaging students in research on urban habitat for pollinators. *AustralEcology*, *43*(6), 635-642.doi: https://doi.org/10.1111/aec.12608

Schönbrodt, F. (2019). Training students for the open science future. *Nature Human Behaviour, 3*(10), 1031. doi: 10.1038/s41562-019-0726-z.

Silva, C., Monteiro, A. J., Manahl, C., Lostal, E., Schäfer, T., Andrade, N., ...& Brito, R. (2016). Cell Spotting: educational and motivational outcomes of cell biology citizen science project in the classroom. *Journal of Science Communication*, *15*(1), A02.

Smallman, M. (2018). Citizen science and responsible research and innovation. In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds), *Citizen science: innovation in open science, society and policy* (pp. 241-253). UCL Press.

Stern, M. J., Powell, R. B., & Hill, D. (2014). Environmental education program evaluation in the new millennium: what do we measure and what have we learned?. *Environmental Education Research*, *20*(5), 581-611.

Stevenson, R. B., & Stirling, C. (2010). Environmental learning and agency in diverse educational and cultural contexts. In Stevenson, R. B., & Dillon, J., *Engaging environmental education: Learning, culture and agency*, (pp. 217-237). Brill Sense.

Tauginienė, L., Butkevičienė, E., Vohland, K., Heinisch, B., Daskolia, M., Suškevičs, M., ...& Prūse, B. (2020). Citizen science in the social sciences and humanities: the power of interdisciplinarity. *PalgraveCommunications*, *6*(1), 1-11.

UNESCO (2017).*Education for Sustainable Development Goals: learning objectives*. Paris: UNESCO. Available online:https://unesdoc.unesco.org/ark:/48223/pf0000247444?posInSet=2&q

UNESCO (2019).*Framework for the Implementation of Education for Sustainable Development for the Period of 2020–2030*. Available online: https://unesdoc.unesco.org/ ark:/48223/pf0000370215

UNESCO. (2020). *Education for Sustainable Development: A Roadmap*. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000374802

UNESCO (2021).*Recommendation on Open Science*.Available online: https://unesdoc.unesco.org/ark:/48223/pf0000379949.locale=en

Weinstein, M. (2012). Schools/citizen science: A response to "The future of citizen science." *Democracy & Education, 20*(1).Article 6. Available online at: https://democracyeducationjournal.org/home/vol20/iss1/6/

Zint, M. T., Dowd, P. F., & Covitt, B. A. (2011).Enhancing environmental educators' evaluation competencies: insights from an examination of the effectiveness of the My Environmental Education Evaluation Resource Assistant (MEERA) website. *Environmental Education Research*, *17*(4), 471-497.