ENGAGING TEACHERS IN THE CO-DESIGN OF EDUCATIONAL SCENARIOS AIMING TO INTEGRATE CITIZEN OBSERVATORIES TECHNOLOGIES INTO SCHOOL-BASED ENVIRONMENTAL EDUCATION

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Abstract

Current sustainability issues, such as climate change, biodiversity loss and environmental pollution affect human and ecosystem health and activity and undermine the function and cohesion of local communities. The inherent difficulty of addressing such challenges requires a range of interventions as well as their integration at various levels. Citizen science and environmental education can both address and promote sustainability by developing synergies to engage people, youths in particular, with learning about and dealing with them. In this paper, we argue that developing synergies between citizen science and environmental education is not only possible and compatible due to their many common points of reference, but also for the benefit of education and the collective efforts towards sustainability.

The work presented here has been conducted within the context of the European project Cos4Cloud. The Cos4Cloud's vision is to boost citizen science through the support of citizen observatories. Citizen observatories are community-based monitoring and information systems that enable citizens to collect and share observations mainly of an environmental content. Among their key features are citizen participation in environmental monitoring, "in situ" observations from the citizens, and the use of mobile and web technologies. One of the project's goals is to foster the broadening of the scope of current citizen science practice based on citizen observatories through their integration into school-based environmental education. Here we focus on one action of the general strategy adopted towards this end, which is the co-design of six educational scenarios by six groups of Greek teachers and other educational stakeholders respectively. They were invited to think in terms of the synergies they had to develop to incorporate some of the citizen science observatories' platforms participating in the project into environmental education practices that foster environmental, scientific, citizenship and digital literacy of their students. Each scenario centred on a different topic and environmental issue and offered a detailed description of a proposed way of implementing citizen science in schools, using the project's citizen observatories' platforms. All scenarios were accompanied by creative and pedagogically informed activities and employed a range of integrated and interdisciplinary approaches to learning, encouraging students to engage in action learning and use the outcomes of their learning to improve their school and local environments. In this paper, we describe the co-construction process and its outputs - the scenarios - and discuss the four levels proposed for integrating the Cos4Cloud citizen observatories into school environmental education projects and activities.

Keywords: citizen science, environmental and sustainability education, educational scenarios, citizen observatories, co-design, sustainability, Cos4Cloud European project.

1 INTRODUCTION

Current environmental and sustainability issues, such as climate change, biodiversity loss and environmental pollution, pose significant challenges to 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. In addition, the inherent difficulty of these issues requires not only a range of interventions but also their integration at various levels. Citizen science and environmental and sustainability education are two such interventions that meet at many points of intersection.

Much of citizen science's current practice focuses on engaging adults with science and community action on specific local environmental and sustainability issues and topics ([1], [2]). Defined as work undertaken by, or within, citizen communities with the support and moderation of scientists, educators

and other community stakeholders, citizen science aims to advance science, foster scientific literacy and research competence, encourage democratic engagement and participation, and empower people to join the debate about these issues ([3], [4], [5]). Education and learning may not be among citizen science's first and explicit goals, however, there are many inherent links between them. For instance, both education and environmental protection are public policy issues primarily promoted by many citizen science projects ([6]). Moreover, participation in environmental citizen science projects may involve many more learning outcomes apart from the acquisition of content knowledge and skills related to citizen science per se, such as the increase of scientific and environmental literacy ([7], [8], [9]), or the development of global citizenship, environmental stewardship and community empowerment ([10]).

On the other hand, environmental and sustainability education is a field of educational practice that seeks to facilitate people's engagement in learning about environmental and sustainability issues, not only to develop fundamental scientific concepts, content knowledge and skills for understanding and dealing with current environmental problems but also to nurture values and competences as prerequisites to democratic participation for more sustainable futures ([11]). Participation in individual and collective processes of inquiry on global and local environmental and sustainability issues is thus a central tenet and goal for environmental and sustainability education apart from environmental awareness.

Responsible and active citizen engagement and informed participation to achieve sustainability are also at the core of citizen science ([12, [13]). And this is one of the many commonalities citizen science shares with environmental and sustainability education. However, the synergies between the two remain largely unexplored ([11]). This is why the approach taken in Cos4Cloud project supports the need to focus on, better understanding and promote integration between the two fields through collaborative research, technological innovation and educational practice.

1.1 The Cos4Cloud project: building synergies for networking to promote citizen science

Citizen science offers new means and opportunities to collect different kinds of environmental data to contribute to science, monitor progress towards sustainability and inform environmental governance ([14]). Defined as work undertaken by or within citizen communities with the support and coordination of scientists, educators and other community stakeholders, citizen science aims to promote science, enhance scientific literacy and research competence, encourage democratic engagement and participation, and enable citizens to participate in the debate on complex current global and local sustainability issues ([3]). However, citizen science has not yet reached its full potential as a form of co-construction of scientific knowledge and a collaborative and open valid source of data ([15])]; moreover, although it aspires to enhance education and action for sustainability through its collaborative nature and by enriching mainstream school activities and approaches, these goals remain largely unmet.

Supporting citizen science (a) to increase the scalability, quality and quantity of citizen-generated data, and (b) to establish synergies between citizen science and education for partnership and collaborative action towards sustainability, are among the main goals of Cos4Cloud (Co-designed citizen observatories for the EOS-Cloud), a European Horizon 2020 project ([16]). These goals will be achieved in two ways: first, by creating and supporting a network of citizen observatories through the development of a range of technological services; and second, by aiding and promoting school education to become a key mechanism to introduce citizen science to a wider audience and sow its seeds in new contexts. Both approaches place citizen observatories at the center and capitalize on them.

Citizen Observatories (COs) are research infrastructures (e.g. the technological platforms where a diverse range of tools are developed, such as web portals, smartphone apps, and electronic devices) that allow the development of citizen science projects, in particular those whose main objective is large-scale citizen participation, covering wide geographical areas and long periods of time. The newest forms of observatories integrate the latest information and communication technologies (ICT) to digitally connect the citizens, improve their observational competences and provide information flows ([17])]. Among their key features are that they enable citizen participation in environmental monitoring and governance; a bi-directional flow of data and information; "in situ" observations from the citizens; and the use of mobile and web technologies ([18]). However, citizen observatories face many challenges, such as: the sustainability of citizen participation; the quality of the data generated with respect to the research questions addressed; the management of the scalability of participation; the costs of maintaining the platform; the lack of information flow to citizens who are often unaware of the opportunities available to them to address local environmental issues (how to volunteer, what to do, the existing channels), as well as to public authorities, SMEs and NGOs who are often familial with the potential of COs to support decision-making and create business opportunities; and, finally, the lack of

trust, accountability and reliability of the way data is processed, the way communications are handled and the way ownership issues are addressed ([19]).

The strength of citizen observatories is their capacity to motivate large numbers of people towards a shared goal ([20]). Therefore, the main vision of Cos4Cloud is to support citizen science through the development of a set of technological services that will enable the networking of citizen observatories and help address many of the challenges they face by promoting:

- *Data quality*, via simplifying expert verification or using AI to improve identification;
- *Data interoperability*, through facilitating integration between data sets;
- *The sustainability and maintenance of citizen observatories*, through for example low-cost tools that can be used, adapted and replicated.

Cos4Cloud will therefore act as a minimum viable ecosystem (MVE) for participating citizen observatories and the co-designed and prototyped services to test whether the interactions among the different components have a synergetic benefit for all stakeholders (see Figure 1). A full description of each service is available on the project's website ([21]). Once ready (in 2023), they will be uploaded to the European Open Science Cloud (EOSC) as modules, so that any citizen science observatory can select and install the services it needs to improve its functionalities. As networks, citizen observatories provide an enhanced experience: participants feel "part of something bigger" without losing their connection to local issues.

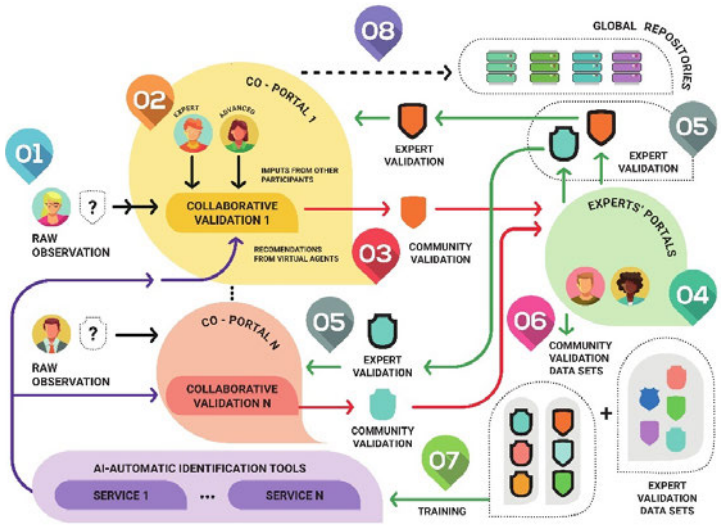

Figure 1. The Cos4Cloud MVE.

Alongside the Cos4Cloud's main goal to support the networking of citizen observatories through the development of technological services, the project promotes networking within school education to expand citizen science practice beyond the traditional adult audiences through the engagement of educational communities. To this end, a strategy of integration building on the symbiotic relationship between citizen science and environmental education has been designed based on the use of the technologies and services of the Cos4Cloud project. This strategy (see Figure 2) 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 schoolteachers, educators, educational stakeholders and schools that are willing to support the integration of citizen science through environmental education projects and activities;

b) The provision of teacher training programs and resources to empower teachers to integrate citizen science into their teaching practices; and

c) The design and implementation of a range of educational projects and activities in schools and their evaluation in terms of their learning potential and educational impact.

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 citizen science initiatives in their local environments.

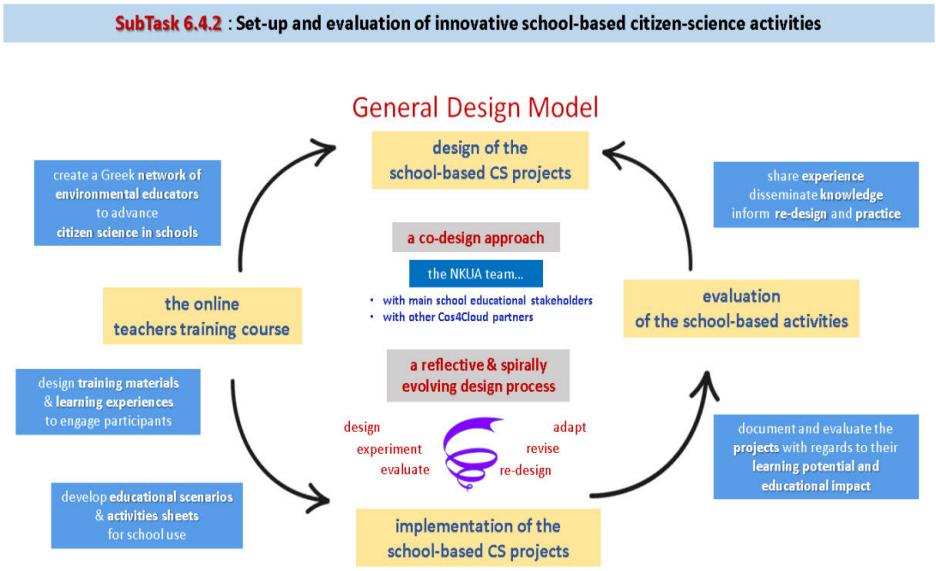

Figure 2. The Cos4Cloud Design Model of integrating citizen science into school education.

The aim of this strategy is that through a range of actions, schoolteachers will engage their students in educational projects on current environmental challenges that draw on the use of the citizen observatories participating in the Cos4Cloud project and the technologies developed within it. Moreover, another aim is that school citizen science projects would go beyond monitoring, for example, urban biodiversity, to support students to get engaged in inquiry-based learning about and for environmental and sustainability issues. Cos4Cloud plans to develop this methodology across other citizen observatories to propose a model of how the integration of citizen science technologies can foster quality education in the context of education for sustainable development across Europe. Finally, by creating networks of citizen observatories and supporting them with interoperable technology through projects such as Cos4Cloud, these benefits can be multiplied and students will be able to contribute to, make use and develop a more comprehensive knowledge based on the improved quality and quantity of data collected.

One of the project's actions that seeks to broaden the scope of current citizen science practice and the use of citizen science observatories through their integration into school environmental education is the co-design of educational scenarios proposing ways of integrating the project's citizen science observatory platforms into school environmental education projects and activities. In this paper, we describe the process of co-designing 6 educational scenarios and their outputs - the scenarios - and discuss the four levels of integration proposed for integrating the Cos4Cloud citizen science observatories into school-based environmental education projects and activities.

2 METHODOLOGY

2.1 The context

The co-design process took place within the context of an online training course for Greek environmental school educators and stakeholders. Organized under the auspices of the Cos4Cloud project the course was carried out by the Environmental Education Lab of the National and Kapodistrian University of Athens (NKUA) with the technical support of the NKUA's Centre for Continuous Education (CCE). Hosted on the CCE's Open eClass platform the 100-hour was run from July to December 2020. Its main objectives were: (a) to introduce key agents of school environmental education practice 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 environmental and sustainability education; and (b) to involve participants in the co-design of educational projects and activities that contribute to the goals of the Cos4Cloud project, facilitating the implementation of relevant actions in schools.

2.2 Participants

Twenty-two (22) Greek teachers and educational stakeholders took part in the co-design process. They were: 6 primary education teachers, 5 secondary education teachers, 3 primary and secondary

environmental education project coordinators, and 9 environmental educators and teacher trainers based at Environmental Education Centers. Participants were 18 women and 5 men, all experienced environmental educators or in other long-tenured positions serving environmental education in schools.

2.3 The educational scenarios co-design process

After they were divided into six groups of 3 to 4 participants were invited to think and act as “educational designers" of citizen science projects and activities in schools. After being divided into six groups of 3 to 4 people, participants were asked to think and act as ‘educational designers’ of citizen science projects and activities in schools. The idea was to build on their teaching experience, to frame it with new knowledge and skills, and to engage them in the collaborative design (co-design) of educational scenarios and activities for school use by means of selected citizen observatories.

To facilitate the co-design processes and achieve a common working basis, they were given detailed instructions how to collaborate and work, along with two templates designed by the trainers’ team. The ‘educational scenario’ and ‘educational activity’ templates contained several fields and sub-fields and were intended to assist co-designers to reflect on every relevant information for describing and justifying their ideas and suggestions in a comprehensive and codified way. This would make it easier and more transparent to understand, use, reuse or modify the scenarios both for themselves and for any potential future user, and would render the scenarios into a useful and practical tool for every educator who would like to work with citizen science in schools. Moreover, the researchers would have an organized set of materials to analyze in order to study the educational designers’ ways of thinking and outcomes of work.

Participants were encouraged to use at least two citizen observatories: Pl@ntnet and OdourCollect, although they were able to choose any other citizen observatory they wished from those participating in Cos4Cloud. Natusfera was for some groups their third choice and was combined with the other two. Through a series of online meetings (e.g. via Zoom and Webex) each group collected, discussed and structured their initial ideas. Working with the two templates as frames for communicating, reflecting and sharing with each other, each group drafted their scenarios via Google Docs. The final scenarios were uploaded to the eClass platform in January 2021 and were subjected to evaluation by the trainer’s team.

2.4 Analysis of the educational scenarios

The evaluation of the educational scenarios was carried out at different levels. Here, we present the evaluation at the content level. A thematic analysis of the textual descriptions of the six educational scenarios was performed, looking for common and different themes. In the analysis we moved beyond word and phrase counting and focused on identifying and describing explicit and implicit ideas, i.e., ‘themes’, in the data. We then developed codes to represent the identified themes and applied them to the raw data as summary indicators for later analysis ([22]). The analysis was based on several criteria, including the focus and central theme of each educational scenario, the central environmental/sustainable issue addressed, the grade/ class/ age group targeted, the pedagogical use of digital citizen science tools and their added value, the strengths and weaknesses of each scenario development, etc.

3 RESULTS

We present here some of the results from the thematic analysis we performed on the six educational scenarios as the products of the co-design process. More particularly, we (a) identify the defining characteristics of each scenario and provide a brief overview of each scenario's profile; (b) we offer a summary of the scenarios’ strengths and commonalities; and (c) we review and briefly comment on the ways suggested by the scenarios for integrating citizen science into school environmental education practice.

3.1 The educational scenarios profile

Educational scenario 1 aims to familiarize students in the last grades of primary school with how to conduct citizen science with Pl@ntNet to study plant biodiversity in a suburban forest close to their school and in their school garden. The students learn to recognize various plant species and distinguish between endemic and invasive ones. Moreover, the scenario involves them in reflecting on the factors affecting the flora biodiversity; in creating a botanical guide and a botanical path; and in getting in touch with the scientific community. It emphasizes engagement and familiarization of young learners with scientific research and opens school education to the local community.

The environmental issue addressed by *educational scenario 2* is odour pollution in school and the neighbourhood. It makes use of OdourCollect, targets primary education students, and engages them in activities with a playful and sensory experimentation character. Students are invited to carry out sensory walks, to keep odour diaries, to create thematic maps and to consider the impact of unpleasant odours on people's socio-economic life and health, on their interactions with other people and how they perceive their school environment. By emphasizing exploration ('experience'), cognition ('awareness') and action, this scenario draws on the students' emotions and memories of smells in their school/ neighbourhood and propose an 'embodied learning' approach to citizen science students.

Educational scenario 3 also addresses students in the last years of primary education. Based on the use of Pl@ntNet and OdourCollect is involves students with creating thematic maps, constructing digital posters and cards and elaborating a plan for the sustainable redevelopment of a former industrial site. The scenario links scientific observations and measurements based on the use of Pl@ntNet and OdourCollect with local history and popular culture and sheds light to values and human rights. The scenario's idea can also be adapted and evolved into a cross-curricular school garden intercultural educational project and action plan.

Educational scenario 4 links citizen science using Pl@ntNet and Natusfera to a multidisciplinary learning process by transforming the school garden into a learning environment. It defines climate change as a biodiversity problem, highlights individual and social responsibility, and brings the school community (secondary education students and teachers) closer to the academic community. The aim is to create a favourable microclimate at school by applying various measures, such as the construction of a green fence that absorbs noise and chemical pollution. The scenario seeks to involve students with current sustainability challenges starting from their school garden and based on the data collected with Pl@ntNet and Natusfera.

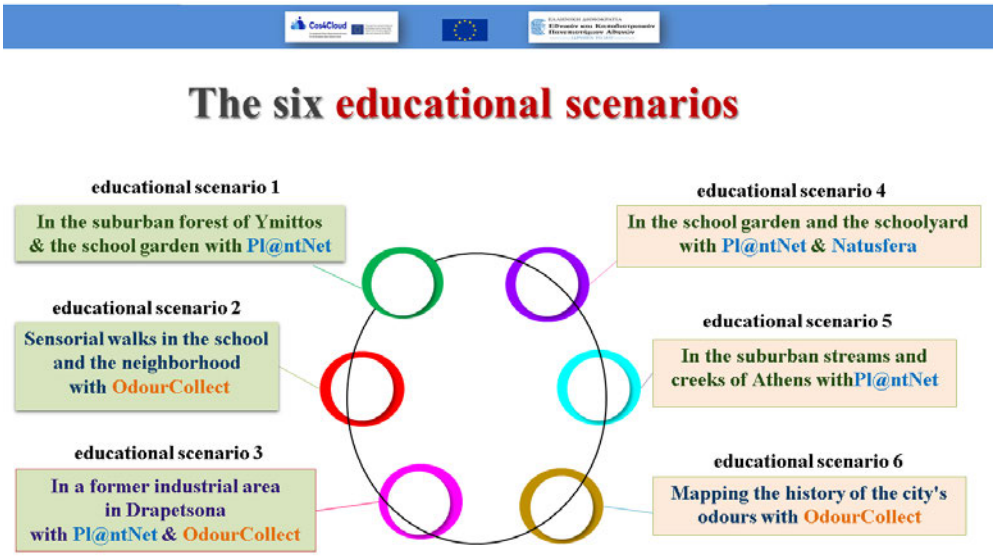

Figure 3. The six educational scenarios.

Educational scenario 5 looks at urban streams and creeks, which views as urban 'isles of biodiversity'. It focuses on the study of invasive/non-native species and involves high school students in identifying plant species in a local stream and creek with the use of Pl@ntNet. In addition to this, the students conduct a literature review search and take a virtual tour of the area. The scenario also includes a visit to an Environmental Education Centre, which runs a similar educational project on streams. By combining inquiry and experiential learning, it focuses on the study of urban biodiversity and emphasizes the students' understanding and familiarization with scientific research and the cultivation of their critical and scientific thinking.

Finally, *educational scenario 6* links citizen science to 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 engage in an interdisciplinary project to highlight the problem of odour pollution in cities through the collection of oral history narratives. In addition, students construct a digital sensory map of place-based odours, which they enrich with local citizens' stories. The aim is to develop a sense of their local community's odours and become motivated to take the role of active

citizens and identify local environmental problems. To this end, students 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 local sustainable development.

3.2 Strengths and commonalities

Each of the six scenarios is unique in terms of the theme and scope employed and focuses on a different environmental issue. All scenarios set clearly defined objectives and propose interesting and innovative methods of implementation. They also put forth a variety of approaches. Among the several common quality features they share 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 improving their school and local communities and addressing issues of local concern.

3.3 Ways of integrating citizen science into environmental education practice

Regarding the integration of citizen science into environmental education practice there are four levels proposed by the six scenarios on how to accomplish it, as illustrated in indicative activities of the scenarios:

a) At a *first* level, students are introduced to citizen science and are supported to develop an understanding of the key concepts, to realize the meaning and purpose of 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, which they collected at different areas and settings: at their school, neighbourhood, 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 that make students to get engaged more actively in the educational process.

c) The *third* level involves 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 apply more than one scientific perspectives and combine quantitative with qualitative data, i.e. by conducting interviews and literature reviews or by administering questionnaires, comparing cases, etc.

d) The *fourth* level aspires to a deeper integration of citizen science into educational processes. It aims at empowering 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: i.e., by creating biodiversity trails in their school grounds, asking the Mayor to listen to what they have to say, making tangible suggestions on how to redevelop their local environments, participating in planting activities, writing down the results of their study and presenting them in community outreach activities.

4 CONCLUSIONS

In this paper, we have explored and presented one possibility for citizen science and environmental education to develop synergies in engaging people, notably youth, in learning about and addressing current environmental and sustainability challenges. The work presented here was carried out in the context of Cos4Cloud, a European project whose main vision is to support citizen science through the development of new technological services that enable the networking of citizen observatories and their connection to the EOSC. However, in this paper, we focus on a more specific goal of the project, which is to broaden the scope of current citizen science practice based on citizen observatories by integrating them into school environmental education.

We outlined the rationale for the project's work and our strategy for advancing the integration of citizen science in schools, part of which is the co-design of educational scenarios. In particular, we focused on presenting the methodology for the co-design and evaluation of six educational scenarios by groups of Greek teachers and educational stakeholders, and part of their thematic analysis. The results show, on the one hand, the distinctness of each of the six scenarios and point to their strengths and common features. The analysis identified four levels of proposed ways of integrating citizen science into environmental education practice. The contribution of our approach to expanding and strengthening current citizen science centres on enriching educational practice in schools based on the principles of creativity, empowerment and innovation.

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