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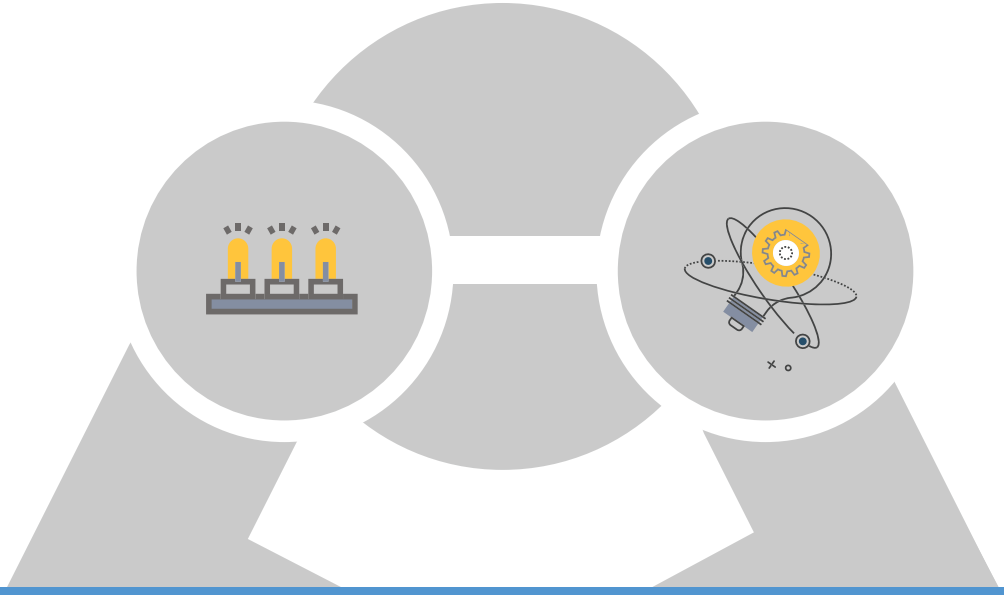

# BRINGING RESEARCH INTO THE CLASSROOM

## THE CITIZEN SCIENCE APPROACH IN SCHOOLS

A SCIENTIX OBSERVATORY REPORT - APRIL 2019

European Schoolnet

BRITEC

BRINGING RESEARCH INTO THE CLASSROOM

SCIENTIX
The community for science education in Europe

Scientix, the community for science education in Europe, facilitates regular dissemination and sharing of know-how and best practices in science education across the European Union (http://scientix.eu). In order to help the development and dissemination of different science education projects Scientix has set up the Scientix observatory which provides overviews on the state of play of different topics related to science education (http://www.scientix.eu/observatory).


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# EXECUTIVE SUMMARY


The way science is approached in the classroom can be instrumental in dispelling negative stereotypes about science and scientific research in young generation. The present report looks at the citizen science approach as an opportunity to connect schools with the world of research to foster a better command of scientific processes in the young, raise their awareness of current issues faced in certain sectors and geographical regions, and help them make sense of the surrounding world. The purpose of this report is to provide educational stakeholders with a baseline for understanding key conditions of successfully implementing citizen science activities in schools.

This report is based on three main sources: (1) a review of recent literature on citizen science and its applications in schools; (2) a collection of citizen science case studies selected by educational organisations in four countries (Belgium, Greece, Poland and Spain) and from the Scientix repository of resources; and (3) the discussions between project managers, project representatives and science educators participating in the 14th Scientix Projects Networking Event (SPNE14), organised by Scientix with the collaboration of four other organisations and projects – GFOSS, Jet Propulsion Theatre, EDU-ARCTIC and ERIS.

The report includes three main sections. The first explores the current literature on citizen science and is guided by three main questions: (1) how do we define citizen science, (2) what are the main actors involved in citizen science projects and how do they participate, and (3) what are the particularities of citizen science activities run in the context of formal education. The second section illustrates 20 citizen science projects, indicating their target audiences and main areas of research, as well as a description of the activities, outlining which part of the scientific method is carried out by volunteers, and, when such information is available, descriptions of the roles and interactions between researchers and citizen scientists. Finally, the third section includes a discussion of the case studies included in the report, with a focus on the main challenges and opportunities of bringing citizen science into schools.

The main difficulty of running citizen science activities in schools which transpired from the report is the issue of balancing research and educational outcomes. For educational outcomes to be achieved, citizen science projects need to go beyond engaging pupils only in data collection and simple analysis, and look to involve them in meaningful research practices, which will give them opportunities to develop scientific inquiry skills. On the same line, if genuine science outcomes are to be met, the 'novice' scientists (teachers and their students) need to be offered opportunities to interact with the researchers in order to be exposed to the requirements of the scientific method and be supported in implementing it. Research suggests that carefully designed projects, created in dialogue between schools (teachers) and researchers, which take into consideration the needs and constraints of both groups, can successfully achieve both goals.

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# INTRODUCTION

## Context of the report

In 2008, the European Commission published its special Eurobarometer entitled "Qualitative study on the image of science and the research policy of the European Union", aiming to assess existing perceptions and attitudes of European citizens related to science and research, as well as to inform future EU actions in increasing citizen involvement in science-related issues. One of the key findings of the report was that, although European citizens seem to value science highly and link it to the idea of progress, it also gives rise to fears and reservations regarding possible misuses, particularly of new scientific discoveries. Moreover, interest in science can be held back by these fears, "as well as by the image of something that is complex and difficult, which calls for prior know-how and prolonged effort, and thus appears quite remote and restricted to the initiated." (European Commission 2008).

Knowledge of and about science correlates positively with positive views of science and scientific research. A more recent Eurobarometer survey (European Commission 2010) showed that those Europeans who "…are interested in and feel informed about new scientific discoveries are much more likely to have a positive view of science and technology than those who are not at all interested or who feel not at all well informed".

As a way of engaging ordinary citizens in scientific research, citizen science can play an important role in opening the ivory tower of scientific research to non-professional audiences. Brought to schools, it is expected to foster a better understanding of scientific processes in young people, raise their awareness of current issues faced by certain sectors and geographical regions, and help them make better sense of the surrounding world.

The way science is approached in the classroom can be instrumental in dispelling negative stereotypes about science and scientific research. The present report looks at citizen science activities carried out in schools in four European countries and elsewhere, with the aim of providing a baseline understanding of key conditions and characteristics of successfully implementing citizen science activities in schools.

## Background to this report

Bringing Research into the Classroom, The Citizen Science Approach in Schools report, is a Scientix Observatory publication produced by Scientix, the community for science education in Europe and BRITEC – Bringing Research into the Classroom – projects.

Scientix promotes and supports a Europe-wide collaboration among science, technology, engineering, and mathematics (STEM) teachers, education researchers, policymakers and other STEM education professionals. Scientix has been running since 2010 organising teacher training activities, dissemination conferences and events, and supporting the exchange of knowledge and experiences in STEM education via its portal, publications and events. Scientix is funded by the European Union's Horizon 2020 research and innovation programme, and coordinated by European Schoolnet.

The BRITEC – Bringing Research into the Classroom – project proposes introducing research into classrooms through citizen science activities, co-designed between schools and research institutions, initially in the four partner countries (Belgium, Greece, Poland and Spain), with a long-term view to massive uptake in Europe and beyond.

An important element of BRITEC is to build an international community of teachers and researchers with the aim of setting the conditions for international collaboration in the field of school education and research.

This report is informed by three main sources:

- A review of recent literature on citizen science and its applications in schools (only publications dated from 2008 onwards were considered, to ensure that only relevant, up to date information is included in the report).
- A collection of citizen science case studies from the national level provided by the BRITEC consortium partners: The Institute of Geophysics PAS (Poland), KU Leuven (Belgium), Universidad Autonoma de Madrid (Spain), IBERCIVIS Foundation (Spain) and GFOSS (Greece), complemented by four other initiatives identified on the Scientix portal.
- The discussions between project managers, project representatives and science educators participating in the 14th Scientix Projects Networking Event (SPNE14), organised by Scientix with the collaboration of four other organisations and projects – GFOSS, Jet Propulsion Theatre, EDU-ARCTIC and and ERIS – on the topic of "Research into the Classroom". The event took place in Athens, on 5 September 2018 and saw the participation of 25 educational projects and organisations: Jet Propulsion Theatre, GFOSS, Institute of Geophysics PAS (EDU-ARCTIC & ERIS), European Schoolnet, Anatolia College, "Zhani Ciko" Upper Secondary School, Varvakeio Model High School, Greek Ministry of Education, 2nd Kindergarten of Perama, Stanimir Veljkovic Zele Elementary/Middle School, APC Microbiome Ireland, Laboratory Center of Physical Sciences of Aigaleo, Hellenic Open University & Computer Technology Institute and Press Diophantus, EU-Track Association, 1o GENIKO LYKEIO AIGIOU, Astronomy and Society Group Leiden University, European School Of Brussels 2, NEA GENIA ZIRIDIS, Liceo statale Scientifico e Classico E. Majorana, NKUA, University of Macedonia, Constantin Brancusi Technical College, A ARSAKEIO LYKEIO PSYCHIKOU, Cell EXPLORERS (NUI Galway), 100mentors and Ellinogermaniki Agogi.

# Report outline

In Chapter 1, we explore the literature in order to better understand the context of carrying out citizen science activities in schools. We first look to identify a working definition of citizen science and how the different actors involved are engaged in citizen science activities. As citizen science initiatives run in collaboration with researchers, we give special attention to the role played by universities or research institutions in the development and implementation of citizen science activities. We conclude our literature review by listing the opportunities and limitations opened by the use of the citizen science approach in formal education.

In Chapter 2 we present 16 citizen science case studies in the four countries represented in the BRITEC project – Belgium, Greece, Poland and Spain – as well as four additional case studies from countries outside the project's four, collected from the Scientix portal.

In Chapter 3 we discuss the case studies included in the report, drawing from the information provided in the literature review. The aim is to better understand the opportunities presented by introducing the citizen science approach in schools and to identify limitations of current approaches.

Throughout Chapters 2 and 3, efforts are made to highlight aspects such as how volunteers are engaged in citizen science projects, how schools and researchers collaborate in these projects, and what are the possible entry points of the citizen science approach in educational curricula. The last section of the report includes the conclusions and main recommendations for moving forward on implementing citizen science activities in schools.

‘When appropriately designed, citizen science can work on massive scales, giving scientists access to amounts of data otherwise difficult to obtain and generating research outcomes increasingly accepted by the scientific community’

# 1. CITIZEN SCIENCE IN SCHOOLS

## What we mean by Citizen Science

Although 'citizen science' projects have been around for decades, the scope and type of activities implied can cover a wide range of models for citizen engagement with scientific work. The term itself is used interchangeably, in different contexts, with others, such as "participatory science" or "community-based participatory research" to refer to the same core set of activities (Eitzel et al. 2017).

Conceptualisations of 'citizen science' range from covering actions referring to citizens' direct collaboration with scientists, for scientific research, to looser forms of public engagement, for example in science popularisation activities, or even in crowdfunding initiatives related to scientific research. For example, the European Commission defines science as follows:

> Citizen science is a broad term, covering that part of Open Science in which citizens can participate in the scientific research process in different possible ways: as observers, as funders, in identifying images or analysing data, or providing data themselves. (European Commission, https://ec.europa.eu/digital-single-market/en/citizen-science)

While the definition proposed by the European Commission reflects the broad uses of the concept and undoubtedly illustrates the European Commission's focus on opening science through encouraging public engagement, research in citizen science notes that the "…active engagement in scientific work differentiates citizen science from other forms of public participation in scientific research where volunteers take less active roles" (Wiggins and Crowston 2011).

Indeed, the active engagement of citizens in citizen science projects is the first item on the European Citizen Science Association's "Ten principles of Citizen Science" (ECSA 2015). Through its decalogue, the European Citizen Science Association (ECSA) proposes a more robust set of guidelines for citizen science activities, considering aspects such as: the nature of the involvement of 'citizen scientists' in research activities and requirements related to the quality of results and to the type of relationship citizen science projects should foster with the research community and the wider society.

However, if ECSA's decalogue serves as a useful guideline for what citizen science projects should strive to achieve, in practice, projects do not always meet all these requirements – for example, project data and meta-data are not always made public, or the way in which volunteer efforts are recognised can vary from one project to the next.

For the purpose of this report, and to differentiate from other types of public engagement with science such as crowdfunding or other science popularisation actions, we borrow Wiggins and Crowston's (2011) definition, where citizen science is "a form of research collaboration involving members of the public in scientific research projects to address real-world problems". Indeed, when appropriately designed, citizen science projects can work on massive scales, giving scientists access to

amounts of data otherwise difficult to obtain and generating research outcomes increasingly accepted by the scientific community (Follett and Strezov 2015). More and more, citizen scientists[1] are being engaged in scientific projects covering different areas of research from biology, astronomy, and the environment, and medical research to name just a few.



### ECSA's ten principles of citizen science

1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.
2. Citizen science projects have a genuine science outcome.
3. Both the professional scientist and the citizen scientist benefit from taking part.
4. Citizen scientists may, if they wish, participate in various stages of the scientific process.
5. Citizen scientists receive feedback from the project.
6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled.
7. Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format.
8. Citizen scientists are suitably acknowledged in projects results and publications.
9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.
10. The leaders of citizen science projects take into consideration legal and ethical aspects of the project.

Full text available here: https://ecsa.citizen-science.net/sites/default/files/ecsa_ten_principles_of_citizen_science.pdf

# Levels of engagement of citizen scientists

Two main types of 'actors' collaborate in citizen science activities: the scientists, who often initiate (and always guide the scientific aspects of) the citizen science projects, and the members of the public who act as the citizen scientists, most often participating on a voluntary basis.

The level of engagement of citizen scientists varies. In this section, we explore the different ways of engagement, by first looking at how the public at large interacts with scientific research, and then trying to close the circle around engagement in citizen science activities in particular.

Probably one of the most respected voices of the international citizen science arena, Muki Haklay, introduced a few years ago the DITOs[2] escalator to describe the different levels of engagement of the general public with science:

1. The bottom of the escalator contains the whole population of a given group (a country, for instance). At this level, the contact with science is usually limited to simple, every-day interactions (such as with the doctors in the hospital).
2. The second level corresponds to that part of the population, which consumes information about science, through TV programmes, websites, newspapers and magazines, etc. In this case, their participation is purely passive, as they do not actively search for science information.
3. A more active role is taken by those that visit, for instance, science museums looking actively to obtain scientific information. They are placed at the third level of the escalator.
4. Those with a limited, but active engagement in scientific activities form the forth level. In this group, we find those citizens that may contribute to search for particular types of flowers, birds, etc. On special occasions, and only on specific areas.
5. The fifth group includes those who actively contribute to demanding citizen science projects such as those classifying stars in Zooniverse[3], cancer cells in Cellspotting[4] or solar images in Sun4all[5], as well as those actively contributing to

[1] We choose the term "citizen scientist" to refer to the population of non-professional scientists engaged in Citizen Science projects.
[2] The DITOs escalator is a central element of "Doing It Together" Science, a European Commission funded project co-ordinated by UCL Extreme Citizen Science group, aiming to build the institutional and policy foundations for sustained deep public engagement in science and technology in Europe. More information can be found here: https://uclexcites.blog/2016/04/29/introducing-doing-it-together-science-an-eu-citizen-science-project/
[3] https://www.zooniverse.org/
[4] http://pybossa.socientize.eu/pybossa/app/cellspotting/
[5] http://www.euhou.net/index.php/exercises-mainmenu-13/other-astronomy-activities-mainmenu-188/205-sun4all

distributed computing platforms such as BOINC[6] or IBM World Community Grid[7].

6. The sixth group is formed by the people who actively contribute to data collection for biodiversity projects by providing samples of birds, insects or plant populations all over the world, monitoring rivers, etc. These people participate in the project development almost as actively as the professional researchers working on them.

7. Finally, the last level corresponds to the very few people who actively design sensors or parts of DIY experiments. They participate in the projects as actively as the professional scientists do.

From the viewpoint of citizen science, only the last four levels represent the public engagement in citizen science projects. Moreover, it is evident that, as we ascend the escalator, the degree of involvement grows, and, in general, also the intellectual effort and the investment of time required. The issue of how to spark and maintain volunteer participation is an important challenge of citizen science projects.

If the DITOs escalator is useful for identifying the different levels of engagement in terms of participant efforts, other studies (Bonney et al. 2009, Follett and Strezov 2015) highlight the types of activities of citizen scientists in these projects. From this perspective, citizen science projects can be:

- **Contributory,** where participants contribute mainly to data collection, and sometimes help analyse the data and disseminate results
- **Collaborative,** where participants carry out data collection, but in addition contribute to data and sample analysis, and sometimes help design the study, interpret the data, draw conclusion and disseminate results.
- **Co-created,** where citizens participate in all the stages of the project, in addition to – on top of the actions described at the previous levels – defining the questions, gathering information, developing the hypotheses, discussing the results and answering new research questions.

Bonney et al. (2009) particularly looked at these three dimensions in order to gauge their potential for informal science education. Whilst contributory projects contributed to developing participants' data collection and analysis skills, collaborative and co-created models were found to have more impact in increasing participants' understanding of science processes and their skills of scientific investigation, and changing their behaviours toward science and/or the environment. On the other hand, they are also more challenging from the organisational point of view, and more demanding for the professional scientists participating in them.

## The role of universities and research institutions

The second type of 'actors' engaged in citizen science projects are the professional scientists, who very often lead the scientific investigation or, in collaborative and co-created models, bring their expert knowledge to guide the scientific aspects of the research project. In their chapter on "Integrating citizen science in university", Wyler and Haklay (in Hecker et al. 2018) discuss extensively the key role of universities, as places which train scientists and where research projects are being carried out, in supporting citizen science (and we expand their observations to also refer to other research institutions).

Indeed, through engagement in citizen science projects, universities have the chance to overcome the image of being largely detached from society and to become active actors in their communities. Citizen science also offers a change of paradigm, opening new areas of research and allowing access to enormous amounts of data with a granularity otherwise difficult to achieve.

In addition, involvement in citizen science activities offers universities a better way to motivate their own students, who may find it beneficial to become part of a leading research activity as part of their student training. By looking further and trying to engage schoolchildren in data collection, universities can fulfill a wider role in educating young people which goes beyond their own institutional settings. At the same time, citizen science can also offer new sources of funding for research, coming from local, regional or national governments, or even foundations who may prefer to fund research activities which involve a large part of society.

[6] https://boinc.berkeley.edu/
[7] https://www.worldcommunitygrid.org/discover.action

Nonetheless, as a new paradigm, citizen science also challenges the traditional way in which research is carried out, and researchers are not always open to engage in such projects. The reasons vary: researchers may not be aware of the possibility of getting the support of citizen scientists for their research, or may have negative perceptions regarding the scientific use of data collected by non-professional scientists. Burges et al. (2017) note that, despite numerous cases of citizen science research producing data comparable in quality to those collected by professional scientists, common critiques may impact on researchers' decision to get involved in citizen science projects - such as the lack of attention to the study design, inconsistent or suboptimal training of participants, absent or problematic standardisation and verification methods, or observer and sampling biases. Often, researchers may judge the effort required to engage in such projects too great. Nonetheless, these are challenges that the research community has to (and is equipped to) address in their regular practice, and which can be overcome by careful design and establishing dialogue with the non-professional researchers (Nature News 2015).

## Citizen science activities in schools

While citizen science literature mainly focuses on the engagement of adult volunteers in citizen science projects, there is a growing number of voices endorsing the educational benefits of engaging pupils in citizen science activities, as a way of exposing them to real research practices.

Citizen science in schools is seen as a way of exposing pupils to all the steps of scientific inquiry (beyond just laboratory work or data collection), as well as a way of consolidating teachers' knowledge of scientific techniques. Additionally, participation in real-life science practices is expected to improve students' performance in science, as well as their understanding of how science works (Shah & Martinez 2016). However, in order for learning to take place, it is clear that citizen science projects in schools must go beyond simply engaging students in collecting and analysing data, and look for closer models of collaboration with scientists.

Important differences exist between the projects which are addressed to the general public and those specifically designed for school education, which, in topic-based classifications of citizen science projects form a category of their own: education projects, or curriculum-based projects (see Wiggins and Crowston 2011, Bonney et al. 2016).
An initial distinction comes from the way citizen scientists are involved. In educational citizen science projects, the work of motivating volunteer participation in the project becomes secondary (or is deferred from the researcher to the teachers), since students are invited to participate as part of their school curriculum. On the other hand, the role of the teachers becomes crucial, both to motivate the students to participate and to facilitate communication between them and the professional researcher.

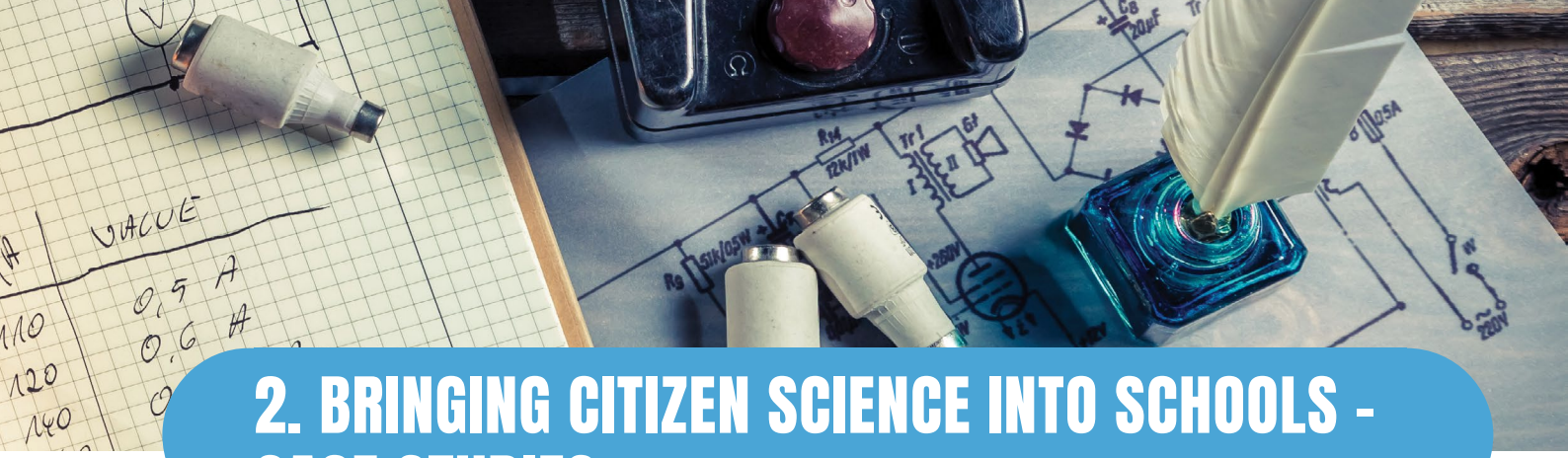
The focus of the project also expands, from having research results as a primary outcome, to including research and pedagogical outcomes. For both to be reached, the working method should be decided in dialogue between teachers and researchers.

If researchers save time in looking for volunteers, they have to put in the extra effort in training teachers in scientific inquiry and science research methodologies. In their article on "Lessons Learned from Citizen Science in the Classroom", Gray et al. (2012) recommend that teachers and researchers engage in explicit discussions about the nature of science related to the existing science curriculum, to ensure that the citizen science activities are meaningful for pupils and teachers alike. Training teachers in how to approach research methodologies in the classroom may be an unplanned effort on behalf of the researchers, but it is also an action which can pay off in the long run, as trained teachers will be in a better position to ensure that good quality data feeds into research.



A paradigm shift is required in schools as well, to "…allow learners to make mistakes and reflective activities that are luxuries rarely available to classrooms and school districts."[8] As Gray et.al. (2012) conclude, "citizen science architects, scientists, teachers, and students will need to develop norms and structures for these collaborations", which, we add, can only be constructed in a collaborative manner, and drawing from previous experiences in these areas.

[8] Gray, S. A., Nicosia, K., Jordan, R. C. (2012).
Lessons Learned from Citizen Science in the Classroom.
A Response to "The Future of Citizen Science". Democracy and Education, 20 (2), Article 14
Available at: https://democracyeducationjournal.org/home/vol20/iss2/14




# 2. BRINGING CITIZEN SCIENCE INTO SCHOOLS - CASE STUDIES

In this section, we present 16 citizen science projects running mainly in Belgium, Greece, Poland and Spain, as well as four international initiatives retrieved from the Scientix[9] portal. It must be noted that not all the projects presented are specifically designed to fit school curricula - of the 20 examples of citizen science projects included, four do not target school education explicitly, nine target general citizens, but incorporate specific actions targeted at young people, and seven are educational projects primarily targeting schools, teachers and their students. However, they all have an important potential for science education, which we explore more closely in Chapter 3 of this report.

For each project, we indicate the target audiences and main areas of research covered, as well as a description of activities, outlining which part of the scientific method is carried out by volunteers, and, when such information is available, descriptions of the roles and interactions between the researchers and citizen scientists. Since we look to find educational gains and possible applications within the school curricula, each project description is accompanied by a short note indicating the educational goals of the project – whether they are explicitly stated, or, when they are not, commenting on the project's potential for classroom use.

[9] Scientix (http://scientix.eu), the Community for Science Education in Europe, promotes and supports a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other STEM education professionals. Scientix has been running since 2010 organising teacher-training activities, dissemination conferences and events, and supporting the exchange of knowledge and experiences in STEM Education via its portal, publications and events. Scientix is funded by the European Union's Horizon 2020 research and innovation programme, and coordinated by European Schoolnet.

# INTERNATIONAL INITIATIVES (INCLUDED IN THE SCIENTIX RESOURCES REPOSITORY)

## 5T - Finland

### Project description

In 2014, the Finnish Meteorological Institute started the co-operation with upper secondary schools within the framework of the *5T* project funded by the Ministry of Education and Culture (Science Education in Secondary Schools by Research with Researchers). The project ran between 2014-2015, involving several upper secondary schools from all over Finland.

Within the project, high schoolers participated in ongoing research projects with topics such as snow measurements, pollen diffusion, climate actions and space weather. Their tasks included making observations, collecting information and proposing new ideas. Researchers were responsible for designing the research tasks and guiding and evaluating the scientific work of the students, while teachers were responsible for integrating the research tasks into school courses. Site visits to the research institute were part of the project, but most of the tasks were conducted independently and guided remotely.

### Educational goals

In addition to involving student in data collection, the project offered a number of learning materials to help teachers discuss climate change in secondary education. Materials included lesson plans, student materials, researcher videos, comics and infographics that teachers can use and adapt to a variety of disciplines to help students understand what are the effects of climate change, explore climate fluctuations in the geological timeframe, and use data visualisation techniques for climate research.

- **Web:** http://ilmasto-opas.fi/kansalaistiede
- **Scientix:** http://www.scientix.eu/projects/project-detail?articleId=481655
- **Target audience:** general public, schools
- **Main subjects/areas covered:** Earth Sciences

# Spot a sparrow - Malta

## Project description

*Spot A Sparrow* is a citizen science project supported by BirdLife Malta that involves the Maltese community in researching one of the most common urban birds in Malta, the Spanish sparrow, to identify the main roosting trees across the islands. The project is especially interested in mapping sparrow roosts, where sparrows gather in autumn and winter evenings to sleep. Trees used for roosting are easy to identify, as the birds become really loud right before going to sleep. The project plays an important role in identifying patterns of bird location so that the birds can be better protected.

Citizen scientists are asked to document sparrow sightings in their local environments and report their exact location through the dedicated platform on www.spotasparrow.org, while providing contextual information about the sighting in a comment box. The trained project surveyors verify the roost, and add the volunteers' observations into final reports.

- **Web:** https://spotasparrow.birdlifemalta.org/
- **Scientix:** http://www.scientix.eu/projects/project-detail?articleId=448552
- **Target audience:** general public, schools
- **Main subjects/areas covered:** Biology, Environmental Sciences

## Educational goals

*Spot a Sparrow* is a citizen science project looking to involve the general population in collecting data which will feed into research. While some of the activities can certainly be run by teachers in schools, there is no direct educational goal the project looks to achieve. Rather, the aim is to create a community project to draw attention to the importance of the trees used for nesting, and protect them from real-estate development.

# VIGIE-NATURE ÉCOLE (France)

## Project description

Launched in 2010, *Vigie-Nature École* is a programme of participatory science run by the National Museum of Natural History in Paris, which explores the surrounding biodiversity.

Teachers and students have the chance to enroll in a number of citizen science projects, particularly designed for school use. Each project offers all needed material for classroom implementation: from background information, to experimental protocols and FAQ sections to support teachers and students in implementing the projects. Teachers and students are exposed to the scientific approach every step of the way; as teachers follow the experimental protocols, students have an opportunity to learn about the biodiversity around them and strengthen their observation skills.

This approach helps students understand the mechanisms needed to build scientific inquiry. The proposed protocols stimulate the students to act, think and conceptualise. In this way, pupils are encouraged to discover and understand the world that surrounds them, and develop all the competences needed to become better informed citizens.

## Educational goals

As *Vigie-Nature École* is primarily an educational project, the educational goals are explicitly stated. The project aims to offer primary and secondary teachers the means of addressing, in their classrooms, issues related to the impact of human activities on ecosystems.

By promoting teaching methods that look beyond the textbook, *Vigie-Nature École* offers an alternative method of teaching, which allows teachers to implement a more participatory approach in classrooms, and to develop pupils' inquiry skills. It must be noted that, while the project looks to bring teachers and pupils closer to the reality of scientific research, it does not aim to facilitate direct interaction between pupils and researchers.

- **Web:** http://www.vigienature-ecole.fr
- **Scientix:** http://www.scientix.eu/projects/project-detail?articleId=555643
- **Target audience:** schools
- **Main subjects/areas covered:** Biology, Environmental sciences

# OoS - Observatory of Seasons (web)

## Project description

The *Observatory of Seasons* is a citizen science programme running in France since 2006, open to the general public, which aims to document the role of human activity in global warming and its impact on biodiversity.

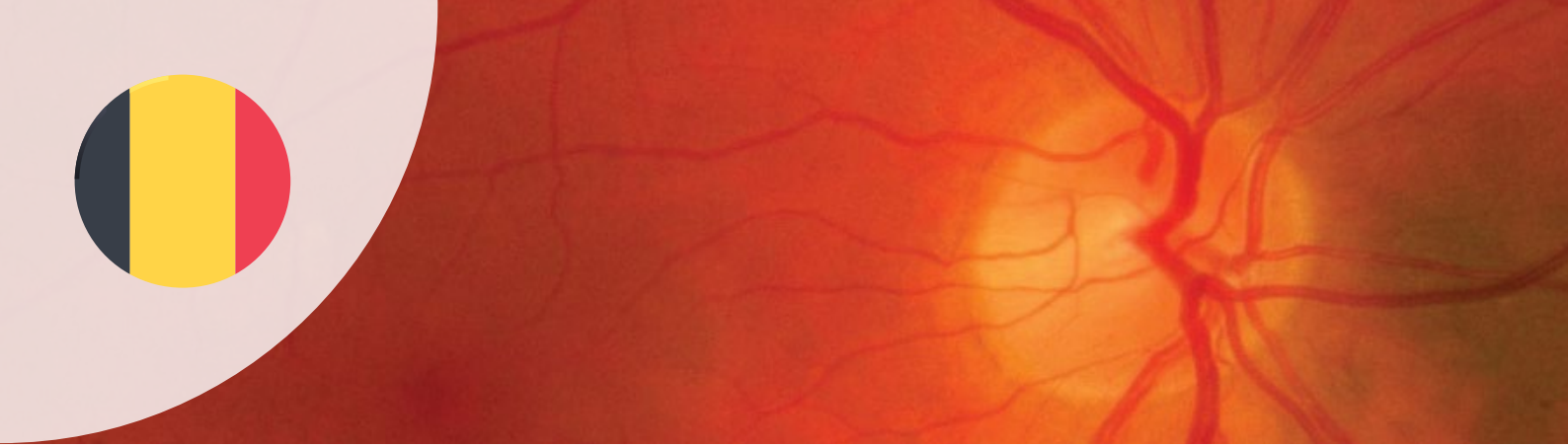
The project engages volunteers in documenting the life rhythm of plants and animals based on seasonal climate variations. Without the need for prior knowledge or specific material, citizen scientists are encouraged to submit their observations according to a simple protocol developed by researchers and scientific mediators. To participate in the project, volunteers are asked to register on the project website, identify particular species and enter their observations into a database.

The data collected is presented on the *Observatory of Seasons* and made available for scientific research.

- **Web:** http://www.obs-saisons.fr
- **Scientix:** http://www.scientix.eu/projects/project-detail?articleId=375317
- **Target audience:** general public, schools
- **Main subjects/areas covered:** Biology, Environmental Sciences

## Educational goals

As is the case of other purely citizen science projects, *Observatory of Seasons* does not include any specific educational goals. However, teachers can implement these activities with their students as part of their biology lessons. The data collected can also be analysed in Mathematics or ICT classes.



# Initiatives in Belgium

## Eye for Diabetes

### Project description

Eye for Diabetes[10] is a 18-month publicly funded project by the Belgium-Flemish government, department Economy Sciences & Innovation (EWI), coordinated by the Flemish Institute for Technological Research (VITO), in partnership with Vrije Universiteit Brussel, Wtnschp, the science communication expertise centre in Brussels and Diabetes Liga. The project was launched in February 2019, and it aims to create a computer model based on artificial intelligence to be able to detect early signs of diabetic retinopathy. This computer model can only be trained successfully by supplying it with a huge amount of example images on which the signs of diabetic retinopathy have been labelled by humans. Early signs of diabetic retinopathy can be subtle and difficult to spot, even for well-trained specialists.

VITO, the Flemish Institute for Technological Research, is developing MONA - software capable of analysing photos of the retina and recognising symptoms of diabetic retinopathy. The ambition is to use MONA in the future in first-line screening at the optician, doctor or pharmacist. They can then refer persons with an indication for the disease for further examination by the ophthalmologist. This way diabetic retinopathy is detected faster and a preventive approach leads to better cooperation in the health sector.

The project mainly targets volunteers from Belgium (Flanders), but the application is also launched internationally to involve additional participants. Volunteers are asked to help perform annotations on medical images (retinal images), estimate the quality of the images, mark landmarks (blind spot and yellow spot) and detect symptoms of diabetic retinopathy. Volunteer feedback is collected via the Zooniverse[11] platform, which incorporates volunteer training and discussion boards where volunteers can ask questions and exchange with the researchers.

### Educational goals

Eye for Diabetes has mainly researcher-centred goals. In the area of science, the project aims to document patterns of retinal images in order to train a computer model based on artificial intelligence to detect signs of diabetic retinopathy. Another important objective is to create awareness among patients with diabetes, family members, healthcare providers and the population at large about diabetes, its complications, and more specifically eye health, as well as to increase the knowledge and involvement of citizens in biomedical sciences.

While applications in formal education can be explored, particularly in secondary school Biology classes or in Computer Science classes (as an example of the use of machine learning systems), there is no explicit component targeting formal education.

- **Web:** https://www.oogvoordiabetes.be/
- **Target audience:** general public
- **Main subjects/areas covered:** Public Health, Medicine, Computer Sciences

[10] Project website: https://www.oogvoordiabetes.be/. The project in Zooniverse: https://www.zooniverse.org/projects/oogvoordiabetes/eye-for-diabetes (Dutch and English versions available)

[11] Zooniverse (https://www.zooniverse.org/) is, according to its website, "the world's largest and most popular platform for people-powered research". The Zooniverse web portal hosts a large number of projects, covering many disciplines and topics across the sciences and humanities.

# Familiekunde Vlaanderen

## Project description

*Familiekunde Vlaanderen* is a large genetic genealogical project running since 2009 in Belgium (Flanders) and the Netherlands (with several different initiatives, such as the "Benelux DNA-project", "De Gen-iale Stamboom", "Idesbald Project", among others). The project covers areas such as genetic genealogy, population genetics and historical demography, and is being run by a partnership between KU Leuven, Familiekunde Vlaanderen (NGO) and Histories vzw (NGO).

*Familiekunde Vlaanderen* combines genealogy with genetics to provide insights in biological relatedness and genetic effects of historical migrations since the 16th century. Citizen scientists are engaged in collecting extensive genealogical data in archives, and they do this for thousands of families for which genetic data exist. Thanks to this unique combination of in-depth genealogical and genetic data, more than ten peer-reviewed publications on topics such as historical extra-pair paternity and cuckoldry, genetic effects of migrations before, during and after the 80 Years War and the Industrial Revolution in the Low Countries, and the forensic applications of genetic genealogy.

- **Web:** https://familiekunde-vlaanderen.be/
- **Target audience:** general public
- **Main subjects/areas covered:** genetic genealogy, population genetics, historical demography

## Educational goals

The project's goals are strongly research-centered. Volunteer engagement is animated through discussion forums available on the platform, and through local events and Talk Cafés. While project activities could be incorporated in secondary schools biology/genetics classes, the project does not specifically target school education.

# SPIN-CITY (SPIDER-CITY)

## Project description

*SPIN-CITY*[12] *(SPIDER-CITY)* is a citizen science project launched in November 2011, coordinated by Ghent University. The project's primary focus is on the Flanders region, although the coordinators are also investigating the possibility of launching the project internationally.

In *SPIN-CITY* spiders are used as natural barometers to investigate two relevant issues of city living: (i) heat island dynamics through spider colour and (ii) the loss of insect populations by investigating web characteristics. The expectation is that spiders will have a lighter colour in urban areas that are more hot because of the higher amount of dark covering (such as concrete and asphalt) when compared with rural spiders. In a similar vein, it is expected that spiders construct webs with a finer mesh size in cities to account for a lower amount of flying prey, thus increasing their capture efficiency.

Citizens involved in the *SPIN-CITY* project are responsible for data collection through taking pictures of spiders in both rural and urban settings through a specifically designed app. Pictures will also be analysed using the citizen community on a dedicated website. The results will analysed by Ghent University scientists and will be available on the website through interactive maps and charts. This way, citizens can play around with their own data and, for example, be able to determine how many spiders have been found in their area and what colour/what kind of web they have built.

## Educational goals

In this project, research and educational goals are both evident. The project will develop educational packages specifically targeting schools that will allow interested teachers to set up their own research project and have their students investigate spider colour and web through excursions or by giving assignments to be performed in their gardens. Background information on urbanisation, heat island, spiders, web building, etc. will be provided so teachers have the opportunity to include this in the classroom curriculum. These educational packages will be aligned with the national curriculum as much as possible, but will most likely be developed for broad age groups, allowing teachers the flexibility to tailor their use according to specific educational goals.

- **Web:** N/A
- **Target audience:** general public
- **Main subjects/areas covered:** biological sciences, Environmental sciences

[12] https://ewi-vlaanderen.be/oproep-citizen-science/spinnen-als-natuurlijke-barometers-de-stad-spin-city

# The VLINDER project

## Project description

*The VLINDER project* is coordinated by Ghent University and includes various scientific (RMI, VITO), technological (AllThingsTalk) and educational (such as Technopolis) partners. The aim is to investigate the influence of the local environment on the weather (e.g. urban heat island, impact of greenery and water on temperature, among others).

Supported by citizen science funding from the Flemish Government, Department EWI, the project specifically targets schools. Fifty weather stations are therefore distributed over schools in Flanders, which will have to build the station and install it at an interesting location in their environment. Schools have to suggest locations in the enrolment stage and the quality of the proposed locations will be an important selection criterion. Once the network is operational, schools will be able to investigate their measurements and compare them with nearby locations in different landscapes. Educational material on weather and climate will be provided to the participating schools.

## Educational goals

The project aims to have an operational network of weather stations collecting measurements and analysing data by November 2019. Schools and pupils will be actively involved in data collection and analysis, and their participation is expected to contribute to enhancing student knowledge about weather and sensors, as well as their data analysis and ICT skills. The project also answers a need for more educational content about the weather and climate, at a time when schools and students are expressing their concerns about climate change and other environmental issues.

The educational materials provided to schools will be constructed by taking the national curriculum into account; possible entry points in the curriculum are physics, geography and STEM classes.

- **Web:** www.vlinder.ugent.be
- **Target audience:** schools
- **Main subjects/areas covered:** Earth Sciences, Environmental Sciences, Engineering

# Initiatives in Greece

## The Ecomobility Campaign

### Project description

The *Ecomobility Campaign* is an annual initiative run by the ECOCITY Voluntary Organisation for the Urban Environment[13] engaging the participation of young people (specifically Junior High School students) in finding solutions to the problems of travelling to the major cities of the country, with the main aim of raising awareness of community issues among all citizens.

During the campaign, students are required, on their own and without adult intervention, to present their research, their work and the solutions they propose in the way they choose. Their work can be accompanied by a theatrical performance, song, lyrics, various constructions, models, paintings, or other creative forms of presentation.

Students are asked to prepare their projects, carry out and present their research and propose solutions to improve mobility in their city. The projects are evaluated by expert committee with five members consisting of the associated scientific institutions, the participatating organisations, the local authorities and other relevant organisations. The best proposals are awarded at national level.

In order to complete and present their proposal, students interview citizens and local bodies about the mobility problems in their city, record and visit locations, get in contact with scientists (environmental scientists, transport engineers, environmental engineers, etc.) and finally propose solutions to the responsible authorities.

Over 15 years since the start of the campaign, municipalities and cities have adopted and implemented the students' suggestions to improve citizens' mobility in their city. Through the participation of students, parents, teachers and the wider community, local and national authorities become more active and their awareness is raised concerning problems connected with mobility in their own city. With the completion of the campaign, a report is drafted and conclusions are drawn for tenvironmental attitude and behaviour of adolescents by the scientific team of the Laboratory of Development and Promotion of Financial Products and Services of the Athens University of Economics and Business.

### Educational goals

As with all projects approved by the Ministry of Education in Greece, Ecomobility is designed to fit, directly or indirectly, into national curriculum. Student activities can be embedded in a range of STEM and non-STEM classes, depending on the focus of their projects. It is important to note that since contact with scientists is largely unstructured and left at the initiatives of the student teams, the Ecomobiliy initiative challenges the strict understanding of citizen science as close collaboration between professional and amateur scientists that we propose for this report. However, the initiative remains helpful for understanding aspects of community engagement, which are often encountered in citizen science projects.

- **Web:** http://www.ecomobility.gr
- **Target audience:** schools
- **Main subjects/areas covered:** Environmental Sciences, Engineering

[13] http://www.ecocity.gr/

# Schools Study Earthquakes project

## Project description

The *Schools Study Earthquakes (SSE)* ran between 2015 and 2017, with support from the Erasmus+ Programme under the key action Cooperation for innovation and the exchange of good practices. The project covered five countries (Greece, Italy, Turkey, Cyprus and Bulgaria). Under the coordination of a research institute (the Institute of Geodynamics – National Observatory of Athens), its aim was to create a South Eastern European/Mediterranean School Network of digital seismographs to monitor seismic signals across different regions and countries. The project specifically targeted teachers and pupils, looking to increase student interest in science and to stimulate teachers' motivation to update their pedagogical methods and renew the science curriculum.

The *SSE* network of schools collected and studied real-time earthquake data from 10 seismological stations located in schools in Bulgaria, Cyprus, Greece, Italy and Turkey. Each network station employed the TC1 educational seismometer especially designed for educational purposes and easily assembled by teachers and pupils.

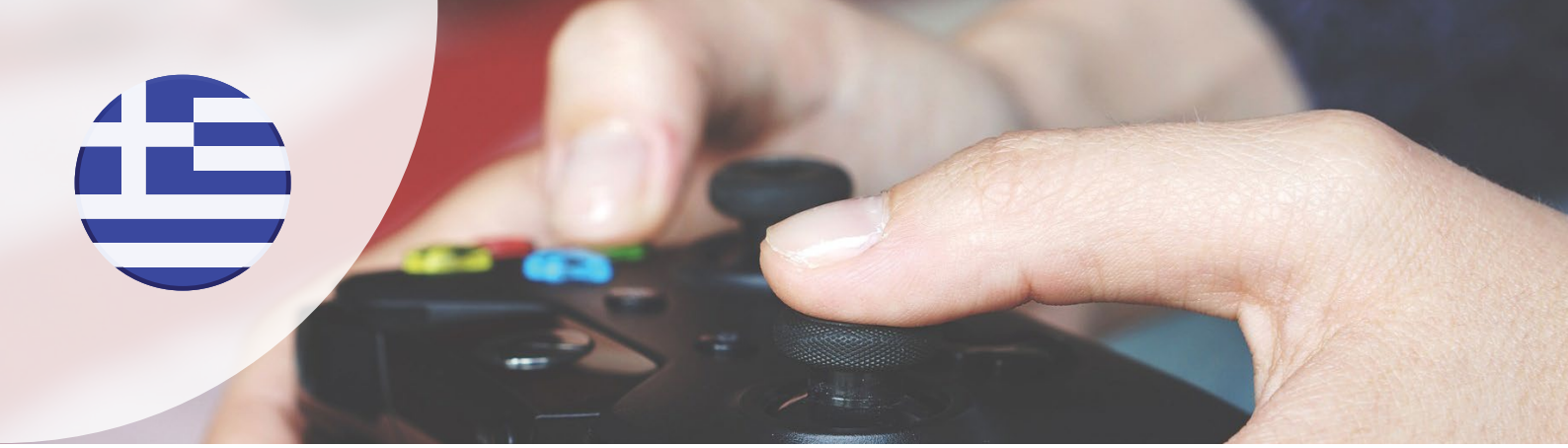
School seismographs were connected to a computer that collects the data. Students collected, analysed and processed parameters of the seismic vibration that had been recorded, such as the location and time of the earthquake, the calculation of its magnitude and the localisation of its focus.

To build on the results of the programme, the Geodynamic Institute of the National Observatory of Athens, in cooperation with the school of EllinoGermaniki Agogi and the support of the Ministry of Education in Greece, continues to organise, every April, an educational contest on the topic "Make your own seismograph" for primary, junior high, upper high and vocational school students. Students must present their findings, which are judged against a number of criteria, such as: scientific correctness, the provision of multiple rendering tools, skills development and perception of civil protection.

## Educational goals

As a citizen science project having education as a primary goal, SSE is purposefully designed to meet learning outcomes. Project partners have taken steps to map the place of seismology in the national curriculum of each project country, and activities are designed to meet these requirements. Project partners jointly developed guides, handbooks and training materials to support teachers in implementing lesson plans and activities around seismology in their classrooms. Project materials were designed to fit a number of classroom subjects, such as Physics, Geology, Geography and Mathematics. The project particularly emphasises the use of the inquiry-based learning methodology, and there is a strong focus on communicating research results to the community. The pupils' interaction with research methods was mediated by their teachers, students having no direct interaction with researchers over the duration of the project.

- **Web:** http://sse-project.eu/
- **Target audience:** schools
- **Main subjects/areas covered:** Earth Sciences



# Games X Palaio Faliro (STEMforYOUTH)

## Project description

In the framework of the *STEMforYOUTH*[14] project, the Eugenides Foundation, in collaboration with the University of Barcelona and the University of Catalonia, and the participation of students and teachers of the 4th High School of Palaio Faliro (in Athens) designed and developed a Civil Science experiment. The entire effort was supported by Palaio Faliro City Council.

Students of the 4th High School of Palaio Faliro, through a co-creation process and under the guidance of the researchers of the Eugenides Foundation, the University of Barcelona, the University of Catalonia, designed a Citizen Science experiment based on their social concerns, knowing that the results of this experiment may have a local social impact.

The subject of the experiment was based on a social event that took place in September 2017 on the shipwreck of the tanker Agia Zoni, which caused the pollution of the Saronic coast as well as of the coast of the city of Palaio Faliro. The experiment also comprises a digital game based on game theory and scientific research. The experiment was carried out in a public space, the Flisvos area, in an experimental facility created collectively by the students, educators, qualified staff of the Eugenides Foundation, a digital platform programmer and scientists. The pupils acted as supporters and facilitators for the citizens who wanted to participate.

## Educational goals

The co-creation process was designed for classroom use, but took place at the Eugenides Foundation in the form of workshops to facilitate the process as well as to achieve the greatest possible involvement of the pupils. The activities were designed to fit curriculum subjects such as Environmental studies, Chemistry, Biology, while the analysis of results can be included in Mathematics, Statistics or Informatics classes. It must be noted that students were actively involved in the research study not only at the data collection stage, but also in defining the research questions and conceptualising the experiment, and in the organisation and planning of the action (Vicens et al., 2018).

- **Web:** http://www.stem4youth.eu/
- **Target audience:** schools
- **Main subjects/areas covered:** Environmental Sciences

[14] *STEMforYOUTH* (http://www.stem4youth.eu/ ) is a European Union Horizon 2020 research and innovation programme which directly engages pupils and schools through a number of activities aiming to raise student interest in STEM studies

# World Wide Data Day

## Project description

*World Wide Data Day* (LHC-W2D2) is an activity of International Masterclasses, QuarkNet and the International Particle Physics Outreach Group, helping to bring particle physics to high school students and teachers through authentic data investigations. LHC-W2D2 lasts for 24 hours, during which students from around the world can analyse data from the Large Hadron Collider at CERN in Geneva and share results via an ongoing, 24 hour videoconference with physicist moderators taking shifts in locations around the world.

Students have the task of searching for particles called muons that result from proton collisions, and measure angles at which they careen from the collision point. All the results are pooled worldwide to probe the nature of proton collisions and reveal something about what is inside a proton. Students who are part of the investigation will join videoconferences with their peers and physicists to discuss what they have learned.

LHC-W2D2 is open to groups of four or more high school students who have the aptitude and interest to analyse data from the Large Hadron Collider. All analyses will be of open, public data from the Large Hadron Collider. After data analysis, each group uploads its results at least 30 minutes before the pre-assigned time or their videoconference. Videoconferences are up to 30 minutes long and consist of up to 5 student groups plus moderators. Each group has 3 minutes to present results. If there is extra time after the presentations and question period, students may stay to chat with the moderators and with one another.

## Educational goals

As in the case of the *Ecomobility* campaign described previously, the LHC-W2D does not fit the strict definition of citizen science we proposed. However, the initiative does provide opportunities for students to interact directly with scientists and discuss their findings, albeit in a pre-defined setting, and for a very brief amount of time. LHC-W2D activities could be incorporated in classroom settings, in subjects such as physics, geometry, mathematics or informatics (as the data are analysed using computers). However, while the project targets youth, and students are indeed encouraged to participate in the LHC-W2D2 with a teacher, the teachers' supervision is not compulsory.

- **Web:** https://quarknet.org/
- **Target audience:** schools
- **Main subjects/areas covered:** Physics, Mathematics

# Initiatives in Poland

## EDU-ARCTIC Monitoring System

### Project description

*EDU-ARCTIC* is an H2020 funded project focused on using Arctic research as a vehicle to strengthen science education curricula across Europe. It aims to encourage students aged 13 to 20 to pursue further education in science, technology, engineering and mathematics (STEM). The project uses a mix of different tools to bring fresh approaches to STEM teaching, one of which is "citizen science" environmental monitoring programme, targeting secondary schools across Europe. The project consortium gathers expertise from 6 countries, with two partners mainly involved in the monitoring system: Institute of Geophysics PAS and the Norwegian Institute of Bioeconomy Research – NIBIO.

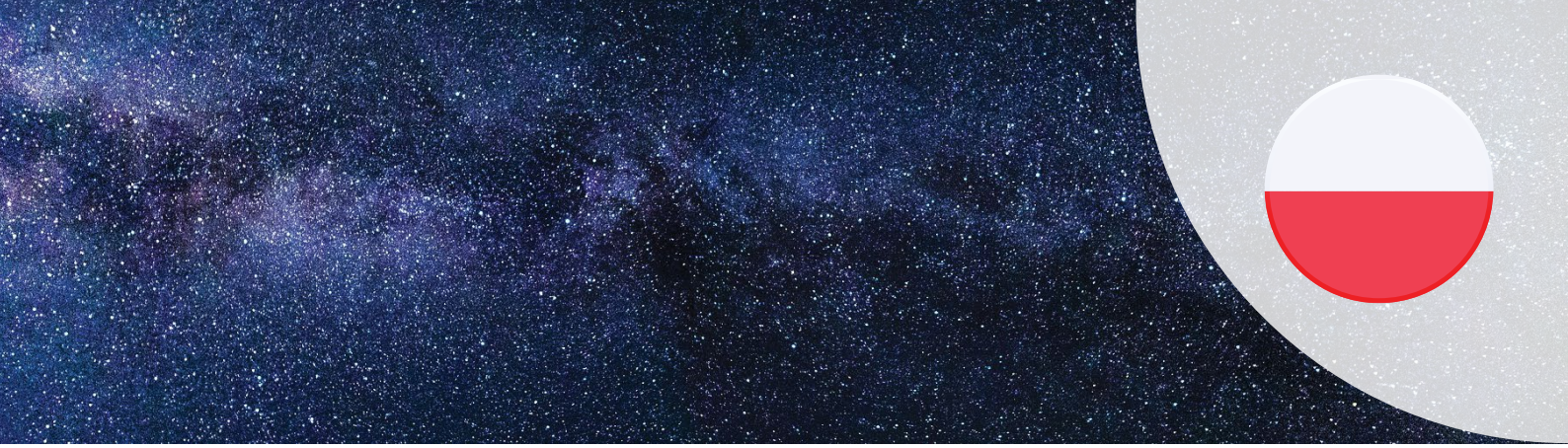
All schools in Europe are invited to participate in meteorological and phenological observations in the schools' surroundings, to report these observations on the portal and to have access to interesting accumulated data. *EDU-ARCTIC* invites schools to become part of a larger effort to gain a holistic understanding of global environmental issues. Students from secondary schools may act as scientific eyes and ears in the field. No special equipment is needed.

With regards to the type of data collected, some meteorological parameters in the *EDU-ARCTIC* monitoring system are reported as actual values: air temperature, cloud cover, precipitation, visibility reduction and wind force. Some other meteorological and hydrological phenomena, which occurred within the previous week: lightning, extreme and other atmospheric phenomena, ice on lakes and rivers and snow cover, are also included. Biological field observations include plants (Birch, Lilac, Bilberry, Rosebay willow herb, Rowan), insects (Bumble bee, Mosquito, Ant, Common brimstone, European peacock butterfly) and birds monitoring (Arctic tern, Common Cuckoo, White wagtail, Crane).

### Educational goals

As an educational project, the data collected through the *EDU-ARCTIC* monitoring system does not feed into research, but the reported information can be downloaded by teachers and used for a variety of subjects, including biology, chemistry, physics and mathematics in secondary schools. Pupils involved in data collection and reporting are directly exposed to the requirements of data collection, and can work, with their teachers, on analysing the results. Moreover, a series of online lessons in the form of webinars conducted by scientists from IG PAS and NIBIO are organised for classes in order to better explain the goals of the observations. In the 2018-2019 school year, a thematic course called Citizen Science dedicated to the *EDU-ARCITC* Monitoring System is being organised.

- **Web:** https://program.edu-arctic.eu/#measurements
- **Target audience:** schools
- **Main subjects/areas covered:** Earth Sciences/Environmental Sciences



# Galaxy Zoo - In Search of Erupting Black Holes

## Project description

*Galaxy Zoo* is a Zooniverse citizen science project coordinated by the Citizen Science Alliance[15], a collaboration of scientists, software developers and educators who collectively develop, manage and utilise internet-based citizen science projects in order to further science itself, and the public understanding of both science and of the scientific process. The project stems from the collaboration among a number of universities and research institutes, among which the University of Western Australia, University of Minnesota (USA), Oxford University (UK), ARC Centre of Excellence for All-Sky Astrophysics, Australian National University, University of Tasmania, CSIRO Astronomy and Space Science, Australia, Adler Planetarium, and others.

Internationally, over 1 million users from around the world are involved in the classification of galaxies, from images provided on the Zooniverse platform. Volunteers are asked to sort out telescope photos of galaxies by shape on the project website, using a computer. The reason why this international citizen science project is included under Polish initiatives is the success of the project with Polish citizen scientists. Over 100,000 users – 10-15% of all users logging daily to the platform – are Polish, whose numbers increased considerably after the translation of the platform in their language.

As it is the case with the other Zooniverse projects, the participation of citizen scientists in the research is always computer mediated. Interactions among volunteers and between volunteers and researchers take place in a virtual discussions forum – the Zooniverse Talk – which is characteristic to all Zooniverse projects.

## Educational goals

*Galaxy Zoo* is a crowdsourced astronomy project, which invites people worldwide to assist in the morphological classification of large numbers of galaxies, with the aim of collecting sufficient observations to understand the processes of the Universe by working out what galaxies can tell us about the history and future. As a citizen science project targeted at the general population, Galaxy Zoo is not designed to fit specific educational goals. However, teachers could include classification activities in Astronomy classes.

- **Web:** https://radio.galaxyzoo.org/
- **Target audience:** general public
- **Main subjects/areas covered:** Space Science, Astronomy

[15] https://www.citizensciencealliance.org/

# Spring Alive

## Project description

*Spring Alive* is an international project to encourage children's interest in nature and the conservation of migratory birds and to get them to take action for birds and other wildlife as well as to participate in events organised by BirdLife Partners. The project began in 2006 as a European project supported by the ERASMUS+ Programme of the European Commission. The project soon extended to Central Asia and, from 2010, includes also Africa. Spring Alive is organised by OTOP, the BirdLife Partner in Poland, on behalf of the BirdLife Partnership.

The project specifically targets children and their families, who are invited to post observations of bird species sightings. By posting their first sightings of Barn Swallow, White Stork, Common Cuckoo, Common Swift, and European Bee-eater on the www.springalive.net website, children from Europe, Central Asia and Africa create a real-time map of the journeys these birds take every year. Since the beginning of the project, 34,000 observations have been reported on the platform.

## Educational goals

With children as main target audiences, the project has a direct educational aspect. The data collected by children is displayed on a real-time map which gradually presents the arrival of spring in different countries, according to the birds' migration patterns. But the project also involves indoor and outdoor events, to engage children, schools and the wider community in the conservation of migratory birds, and to encourage them to support their national BirdLife Partners.

This project's activities could be implemented at all levels of primary school, particularly in biology lessons. Teachers can subscribe to the project website to receive educational materials they can use in class: lesson plans, presentations and games to encourage participation.

- **Web:** http://www.springalive.net/
- **Target audience:** schools, families
- **Main subjects/areas covered:** Environmental Sciences

# Wisła Warszawska (Warsaw Vistula River)

## Project description

The *Wisła Warszawska* project started in 2011, with the support of the European Union's LIFE+ programme, which encourages general citizens and engages schools in observations from a 50 km long part of the valley of the Vistula River in Warsaw and the surrounding area.

Citizens were encouraged to provide information in the field of nature protection of the Vistula areas, based on observations of a selected part of the area in terms of interesting events or threats. The information is sent to the project implementers via a mobile application. Observations include: the concentrations of birds during the migration / wintering period, presence of breeding colonies, particularly vulnerable to anthropopressure, and presence of designated non-breeding species, which should be noted for each appearance (e.g. black stork, white heron).

## Educational goals

The project engages schools by providing educational materials, including lesson plans with activities on the Vistula River and its environment, field trips and art classes for 1-3 grades of primary schools, games, audio files of birds chirping, field worksheets for pupils to directly collect observations and a series of presentations about animals living in the Vistula River valley.

- **Web:** http://wislawarszawska.pl/regulamin/
- **Target audience:** general public, schools
- **Main subjects/areas covered:** Environmental Sciences

# Initiatives in Spain

## Aqua

### Project description

The *Aqua* citizen science project aims to control the quality of the water in various areas of Spain. Thousands of Spanish students are creating a map with the measurements they make of water quality (chlorine, pH, flavour, smell).

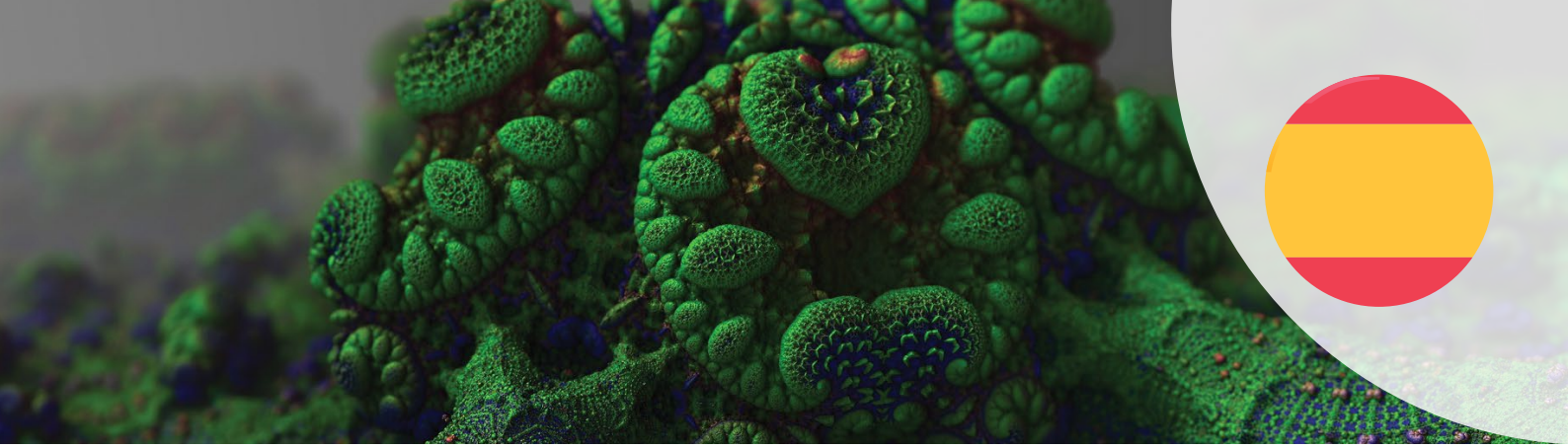
This project brings biochemistry tools and the scientific method to young people who learn about water and its treatments. In addition, a new data source is co-created that presents potential advantages compared to the official periodical monitoring, such as more granularity in time and space (town to town, street to street, tap to faucet) thanks to the work of citizen scientists.

Biochemical kits, including the necessary materials and data collection protocols are sent to 100 centres around Spain, who then distribute them to children who carry out their analysis at home. To share results, volunteers must register to the project website or download a mobile application (IberAqua app). All the information collected is presented on a measurements map, which indicates different indicators of water quality: chlorine, pH, flavour, smell.

### Educational goals

The project directly addresses secondary school students, who are provided with the data collection methodology and supporting videos through the project platform, and with the biochemical kits, distributed through various local centres. While the *Aqua* project does not have specific information tailored for classroom use, the content could be adapted by teachers of different subjects, such as biology, chemistry or technology/informatics.

- **Web:** https://aqua.ibercivis.es/#!/
- **Target audience:** general public, schools
- **Main subjects/areas covered:** Chemistry, Environmental sciences



# Micromascotas (Micropets)

## Project description

*Micromascotas* is a Spanish project, jointly developed by the Instituto de Biocomputación y Física de Sistemas Complejos (BIFI) and the Fundación Ibercivis and funded by the Fundación Española para la Ciencia y Tecnología (FECYT). The project has a regional coverage, data samples being collected from the Spanish city of Zaragoza, and the surrounding area.

*Micromascotas* (micropets) aims to increase the general public's knowledge about the microorganisms that live in our surroundings, such bacteria, fungi, yeasts and mites, as well as the relationship they have with humans and our environment.

Volunteers are engaged in a range of activities, from being asked to collect dust samples and sending them to laboratories, to preparing their own microorganism cultures in Petri dishes and controlling for the right conditions to allow these organisms to grow. Thus, participants get the chance to collaborate in the creation of an open library of microorganisms and better understand the wide range of presence of microbiology in their daily surroundings.

## Educational goals

The project's target audience encompasses the wider population in and around Zaragoza, but activities specifically targeting formal education also took place. For instance, high school teachers were invited to participate in seminars and special sessions to learn how to build functional devices for any laboratory - from magnetic stirrer and hotplates, to microscopes and incubators - with low cost equipment (http://cesaretopia.com/). The *Micromascotas* project can be implemented by teachers of biology and technology, who can adapt the project information to teach these classes.

- **Web:** http://micromascotas.ibercivis.es/?lang=en
- **Target audience:** general public, schools
- **Main subjects/areas covered:** biological sciences, Environmental sciences

# Vigilantes del Cierzo (Cierzo Watchers)

## Project description

*Cierzo Watchers* is a version of the Airbezen[16] experiment, originally taking place in Antwerp (Belgium). The project was run in Zaragoza in 2017, under the coordination of the Ibercivis Foundation, and with support from the Zaragoza local authorities.

Around 1,000 strawberry plants were given to volunteers to be placed at their windows. The volunteers took care of them and after three months they were asked to send back a few leaves. The leaves were examined by scientists who looked to measure the amount of heavy (metal) particles in the leaf. The results were placed in a map of the city and were analysed in collaboration with experts of the Town Hall to find correlations with potential pollution sources. The project is important since it contributes to identifying particulate matter-airborne particles with the diameter smaller than 10 microns – which are more likely to penetrate the lungs.

Particulate matter is normally measured by air monitoring stations present in different points of the city. With the engagement of citizen scientists, these measurements could be taken in a much larger number of areas and create a more accurate map of air pollutants in Zaragoza.

## Educational goals

Although the experiment was designed for general volunteers, school engagement was also foreseen and encouraged. For instance, teachers presenting their teacher's card, were allowed to collect strawberry pots for their entire classrooms. The project activities could be integrated by teachers in subjects such as biology, chemistry or technology.

- **Web:** http://vigilantesdelcierzo.ibercivis.es/
- **Target audience:** general public, schools
- **Main subjects/areas covered:** biology, Environmental sciences

[16] http://www.airbezen.be/

# Fusion: a star on your screen

## Project description

The project ran in 2011 for one year, and helped scientists at the Research Centre for Energy Environment and Technology (CIEMAT) and at the Institute for Biocomputation and Physics of Complex Systems (BIFI) to perform simulations of the plasmas produced in the International Thermonuclear Experimental Reactor (ITER).

Ibercivis adapted the BOINC-computing infrastructure (https://boinc.berkeley.edu/) to design a distributed computing platform which allowed internet users to participate in scientific research by donating unused computer cycles to run scientific simulations and other tasks. Scientists from Ciemat and Bifi created the program which simulates the evolution of the plasma particles moving inside the TJ-II fusion reactor. With large computing power, it is possible to identify design flaws of the geometry of the reactor which can be corrected.

## Educational goals

Apart from being a citizen science project addressed to the general public, the *Fusion: a star in your screen project* also ran a parallel investigation into the didactic possibilities of voluntary computing on a limited number of high school pupils. This research with pupils was carried out as part of a Masters thesis in education. During the intervention, specific didactic material was created on the topic of Nuclear Fusion.

The experiment was conducted on a small number of upper secondary school students as an introduction to clean energy and nuclear fusion and organised in a few sessions in the computer room where the application running the simulation was installed.

The results of the study were presented at the Conference "Enseñanza y divulgación de la Química y la Física" in Madrid, in 2012, and published as the paper "La red Ibercivis como plataforma didáctica" (Ibercivis as a didactic platform)[17]. It was found that students are receptive to the use of ICT and respond positively to being allowed to actively participate in the teaching-learning process. Moreover, the preliminary results showed that this method seems to be very effective from a didactic point of view.

- **Web:** http://www.ibercivis.es/projects/fusion/?lang=en
- **Target audience:** general public, schools
- **Main subjects/areas covered:** Physics, Mathematics, Computer science

[17] Puértolasa, T.U., Gallardob, M.R.C., Escoriaza, J.C. and Gallardo, J.C., 2012. La Red Ibercivis como plataforma didáctica. ENSEÑANZA Y DIVULGACIÓN, p.407. In Spanish at: https://handbook.usfx.bo/nueva/vicerrectorado/citas/TECNOLOGICAS_20/Ingenieria%20Quimica/89.pdf

# 3. DISCUSSION ON CITIZEN SCIENCE IN SCHOOLS

This report has looked at different citizen science approaches which [1] have been developed with clear educational goals in mind, or [2] have extended their scope to include formal education, or [3] have the potential to be included in classroom practices. The variety of citizen science projects open to public participation undoubtedly shows their potential for education. Among the case studies included, perhaps unsurprisingly the most common topic is Environmental sciences, with more than half of the 20 examples touching upon different environmental aspects. However, approaches vary, and their diversity is illustrative of the transdisciplinary nature of the citizen science approach. Examples range from engaging pupils and general citizens to find engineering solutions to environmental problems (like the *Ecomobility Campaign* in Greece), to offering them opportunities to perform simple chemical experiments to evaluate the water quality in their area (like the *Aqua* project in Spain) and to perform different kinds of wildlife monitoring to better understand the effects of human activity on local/regional ecosystems. Other projects in our list tackle more niche areas of research - such as medicine (*Eye for Diabetes* in Belgium-Flanders) or genetics and genealogy (*Familiekunde Vlaanderen*); others encourage participants to share computing resources, or use the fascination of space to attract volunteers to classify galaxies.

In this section, we reflect on the case studies collected in the report and discuss some of the main challenges and opportunities of bringing citizen science into schools.

## Opportunities for pupils, teachers and researchers

As noted elsewhere (Harlin et al. 2018), "connecting citizen science and schools seems like a natural step" – teachers and pupils get opportunities to experience real research, while researchers get access to enthusiastic volunteers (pupils) and team leaders controlling the quality of the data (teachers). However, a recent study published by European Schoolnet showed that traditional direct instruction and paper-based materials are still frequently used in STEM teaching across Europe (Nistor et al. 2018).

Through citizen science activities, pupils are exposed to the scientific method and directly engaged in different stages of scientific research. Citizen science is also well suited for showing pupils that scientific knowledge is acquired through the process of inquiry, rather than being simply a collection of scientific facts and technical terms. With many citizen science projects touching upon important topics – such as the environment, health and medicine – pupils can also better understand how science can provide answers to issues close to their communities. Moreover, exposure to real-life science experiences is expected to encourage students to proceed with science careers (Wyss, Heulskamp & Siebert 2012).

Citizen science can also tackle issues related to the professional development of teachers, opening opportunities for teachers to build their confidence in approaching science teaching beyond the traditional textbook and to connect with specialists in their field.

Scientists can also benefit from exchanging with schools, not only by gaining access to data and resources otherwise inaccessible, but also by contributing directly to developing the skills of their future researchers and having a real impact in their local communities. Scientists involved in public engagement activities also report positive effects on their scientific career, such as a clarification in the understanding of their own research from a different

perspective, improved communication skills and an increased public awareness of their research (Concannon & Grenon 2016).

Another important note refers to the use of technologies in the classroom, as the opportunities opened in this area by the citizen science approach are evident: all projects referenced in this report use e-infrastructures of different complexities to collect data from participants and share results. Online infrastructures are used to facilitate the exchange of information between professional researchers and citizen scientists (like the World Data Day webinars or the 5T researchers' videos), to share protocols and to create spaces where citizen scientists can find support (either from their peers or from professional scientists).

## Untapped potential

Despite their strong potential, many of the opportunities that the citizen science approach could bring for the actors involved remain insufficiently exploited.

The vast majority of the projects presented in the report are contributory, involving volunteers in mostly simple tasks, such as data collection and reporting – which are less likely to increase the participants' understanding of science processes, their skills for scientific investigation or their behaviour towards science and the environment (Bonney et al. 2009). Only in a few cases included in this report were participants (pupils or general citizens) involved in other steps of the scientific process – such as defining the research questions or interpreting the data and drawing conclusions.

While the use of technologies certainly facilitates the development of participatory research, online projects also tend to be more hierarchical, requiring participants to perform limited actions, while sometimes offering limited educational material. As we have seen in the case of the Micromascotas project in Spain, these limitations can be overcome by, for example, providing more opportunities for interaction between schools (teachers and pupils) and researchers, in the form of teacher training, school visits by the researcher, or other forms of dialogue.

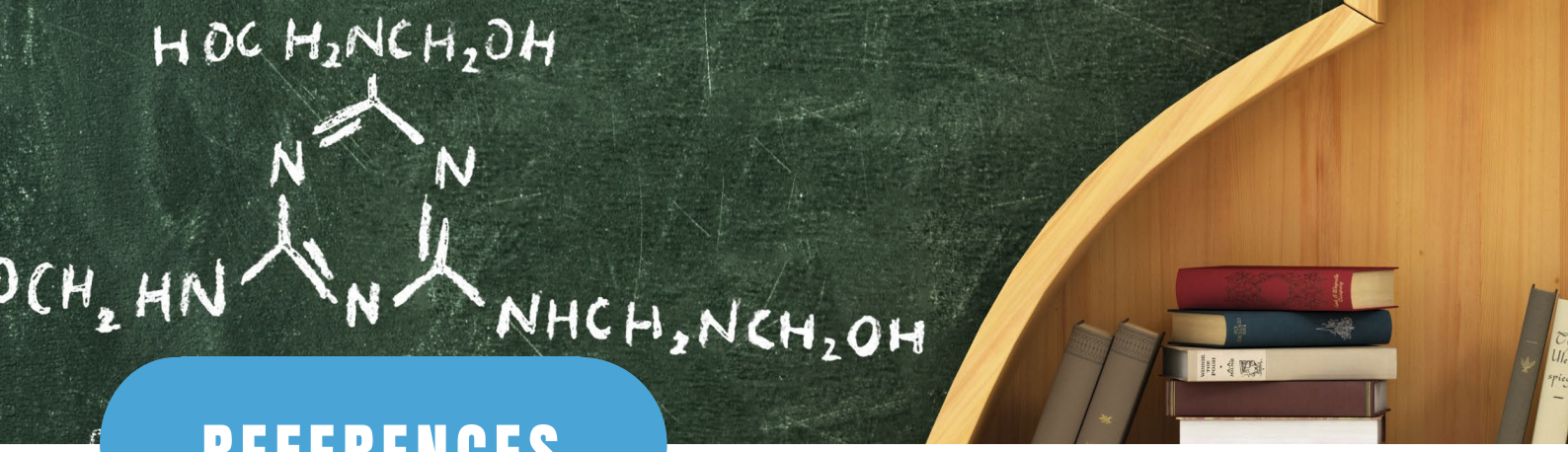
Indeed, in most cases, interaction with researchers rarely goes beyond the provision of scientific protocols or exchanges in virtual forums. Research has shown that carefully designed citizen science projects can have clear learning outcomes, not only in increasing students' scientific knowledge, but also their understanding of scientific practices, their engagement in science lessons and their science and data literacy. However, in order for both research and learning objectives to be met, the projects should be developed taking into account the needs of teachers, pupils and researchers alike. There is a clear need to strengthen dialogue between schools and universities/research institutions, in order to allow teachers to understand the requirements of scientific investigation, while at the same time allowing scientists to understand the classroom and curriculum constraints faced by teachers.

# MOVING FORWARD

Brought to formal education, the citizen science approach provides countless opportunities for all those involved. Pupils are exposed to the scientific method, teachers get professional development opportunities, and universities have the chance to support schools in preparing future scientists from early ages as well as develop their own public engagement activities. More and more, citizen science projects are expanded to include schools and pupils as ways of obtaining valid data and to strengthen their presence in local communities.

However, if citizen science projects must have a “genuine science outcome” to be considered as such (ECSA 2015), when run in schools they also need to meet the requirement of achieving genuine educational goals. The main challenge of running citizen science activities in schools that emerged from the literature review and the review of the case studies included in this report is the issue of balancing research and educational outcomes.

For educational outcomes to be achieved, citizen science projects in schools would ideally go beyond engaging pupils only in data collection and simple analysis, and look to involve them in meaningful research practices, which will give them the chance to develop their scientific inquiry skills. On the same line, if genuine science outcomes are to be met, the inexperienced scientists (teachers and their students) need to interact with the researchers in order to be exposed to the requirements of the scientific method, and be supported in implementing it. Research suggests that carefully designed projects, created in dialogue between schools (teachers) and researchers, which take into consideration the needs and constraints of both groups, have successfully achieved both goals.

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- www.ecocity.gr (in Greek)

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The ‘Bringing Research into the Classroom – Citizen Science approaches in schools’ report is a Scientix Observatory publication produced by Scientix, the Community for Science Education in Europe and BRITEC – Bringing Research into the Classroom projects.

The purpose of this report is to provide a baseline for understanding the key conditions of successfully implementing citizen science activities in schools. The report highlights aspects such as how volunteers are engaged in citizen science projects, how schools and researchers collaborate in these projects, and what are the entry points of the citizen science approach in educational curricula. The report includes the conclusions and main recommendations for moving forward on implementing citizen science activities in schools.

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