Bringing Research into the Classroom

Recommendations

BRITEC
BRINGING RESEARCH INTO THE CLASSROOM

Publisher:	European Schoolnet (EUN Partnership AIBSL), Rue de Trèves, 61, 1040 Brussels, Belgium
Please cite this publication as:	BRITEC Bringing Research into the Classroom – Recommendations
Keywords:	Research, classroom, schools, universities, researchers, research institutes
Authors:	Evita Tasiopoulou, Noelle Billon, Martyna Bajorinaitė, Agueda Gras-Velazquez, Mattia Gentile, Anita Simac, Franca Sormani, Alexia Micallef Gatt, Agata Goździk, Mieke Sterken, María Rebeca Clemente-Gallardo, Jesús Clemente-Gallardo, Panagiotis Angelopoulos, Despina Mitropoulou
Design/DTP:	Mattia Gentile (European Schoolnet)
Picture credit:	Adobe Stock, author adam121

Published in November 2021. The views expressed in this publication are those of the authors and not necessarily those of EUN Partnership AISBL or the European Commission.

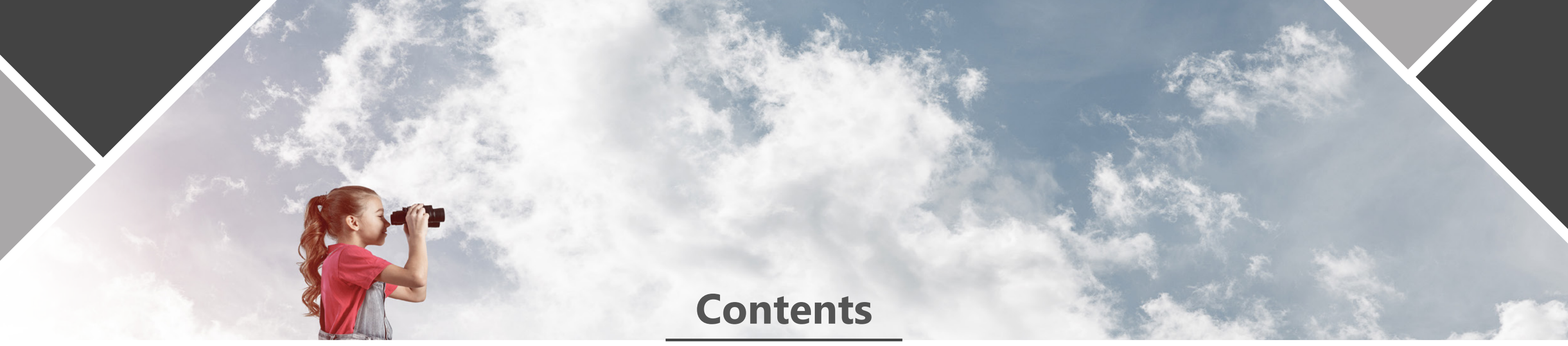
The work presented in this document is supported by the European Commission's Erasmus+ programme – project BRITEC, coordinated by the Institute of Geophysics, PAS. The content of the document is the sole responsibility of the organiser, and it does not represent the opinion of the European Commission (EC), and the EC is not responsible for any use that might be made of this information.

Executive summary

The purpose of the BRITEC Recommendations for different stakeholders is to offer teachers, schools, scientific institutions and policy makers advice on how to bring research into the classroom and how to ensure fruitful collaboration between all parties involved. Moreover, the publication provides an overview of piloting activities in which the Citizen Science (CS) approach was applied in different schools in Belgium, Greece, Poland and Spain in collaboration with and under mentorship of local scientific institutions. The pathways enabling successful CS uptake and the main challenges that emerged are highlighted as well.

Citizen Science offers a wide range of opportunities to both scientific and social innovation. The active participation of the public in scientific research often results not only in scientific advancements such as the production of new forms of knowledge generated, improvement of data and scientific methodologies and increase of scientific capacities in societies, but also in the contribution to solving pressing social issues and enhancement of co-responsibility and co-action between different society members. Various CS projects carried out in cooperation with researchers and the public collect enormous amounts of information and come up with valuable findings regarding local/ national issues of various kinds. These findings become hugely beneficial for policy makers, who, in this way, can draw informed and data-driven conclusions and anticipate a pressing issue by taking necessary actions.

Moreover, CS practices not only bridge gaps between scientists and the public or help address societal issues but also serve as a tool to foster student-centred learning pedagogies such as Inquiry-Based Science Education (IBSE), Project-Based Learning (PBL), Place-Based Education (PBE) and the development of 21st-century skills such as collaboration, communication, critical thinking and problem solving. While projects requiring "minimal involvement" of participants may provide limited space for fostering IBSE, PBL and PBE, those based on an equal footing, or a collaborative approach can benefit immensely from the use of the pedagogies mentioned. Direct contact with scientists in the various stages of CS projects gives students the opportunity to explore "hands on", to experiment, to ask questions directly and to develop responses based on the collected data and reasoning as well as to consider a potential future career in the field. By participating in CS projects, students are engaged in a very dynamic scientific process which stimulates their curiosity and brings them towards seeing science as "their own" product. Consequently, CS participants become learners who pose thoughtful questions, make sense of collected information, and develop new thoughts and ideas about a science topic and the world around them. Through the inquiry, CS participants develop skills and attitudes necessary to be successful, independent learners. Moreover, especially by participating in Citizen Science projects addressing local issues, pupils learn to engage in inquiry, consider different solutions and come up with a proposal which might help in addressing the issue or challenge that is presented. Finally, CS projects are perfect for applying PBL since they involve different stakeholders and often more than one scientific discipline. In this way, pupils learn that real-world challenges are rarely solved using information or skills from a single subject area.



Contents

About BRITEC

Europe's shortage of STEM-skilled labour force is well documented, and the lack of STEM-skilled labour is predicted to be one of the main obstacles to economic growth in the coming years. Furthermore, most European countries are lagging behind in international educational studies such as PISA1 and TIMMS,2 particularly in areas such as science, mathematics and reading.

In this light, there is a real need for innovative approaches increasing pupils' motivation towards STEM subjects and for offering teacher training in new ways of introducing science into the classroom. Additionally, there is still much work to be done in improving the image of scientists at the societal level. Initiatives that help demystify science and connect pupils with real scientists can create a long-lasting positive impact regarding the image of inaccessible scientists who are often seen working solely in the "ivory towers" of the university or other research institutions, lacking direct contact with the public.

Moreover, connecting schools with the world of research is essential in ensuring that the research sector will benefit from much-needed new talent in its various fields, thus having a larger social impact, and that students are thought to think like scientists, weighing evidence to draw conclusions, and learning how to navigate the claims and counterclaims bombarding us in our everyday lives (a crucial need identified through OECD's PISA 2015). An additional impact is foreseen at the level of universities and research institutions, which have the chance to present themselves as active players in local communities, supporting young talent, contributing to scientific and social advancements, and taking a real interest in local issues. Finally, all that has been mentioned will have huge benefits on a social scale.

In this context, and for the last three years (2018-2021) the Bringing Research into the Classroom (BRITEC) project has focused its efforts on introducing the Citizen Science approach in schools as a way of engaging pupils in research practices. In this regard, it also provided teachers with the appropriate pedagogical tools to enable them to teach STEM topics in a contextualised manner, linking research processes and results with everyday teaching practice.

CS is a relatively new way of conducting scientific research, by enlisting the support of citizens into data collection, data analysis, data interpretation and (in rare cases) data presentation. BRITEC offered teachers and researchers from all over Europe the tools and training to bring research into classrooms by engaging pupils in processes of scientific research (from helping to formulate research questions to collecting and analysing information and drawing pertinent conclusions). The current publication presents the outcomes of these efforts, including evaluations as well as recommendations for schools, scientific institutions and policymakers interested in getting involved with CS. The BRITEC consortium hopes that the experience gained, the resources produced and the community of schools, universities and research institutes that was formed will inspire and motivate more stakeholders to get involved in Citizen Science activities as well as enrich the work and efforts of the wider CS community.

1 PISA: Programme for International Student Assessment.
2 TIMMS: Trends in International Mathematics and Science Study.

During the project, a variety of activities have been carried out. These not only led to a series of outputs that contributed to advancing the discussion around the use and role of Citizen Science in the classroom but also offered practical tools and training opportunities to educators interested in including a research component into their daily teaching.

BRITEC publication

In April 2019, the **"Bringing Research into the Classroom – The Citizen Science approach in schools" report** was published as a Scientix Observatory publication produced by the projects Scientix (the Community for Science Education in Europe) and BRITEC (Bringing Research into the Classroom). The purpose of this report was 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 CS projects, how schools and researchers collaborate in these projects, and what are the entry points of the Citizen Science approach into educational curricula. The report also includes the conclusions and main recommendations for moving forward on implementing Citizen Science activities in schools.

https://britec.igf.edu.pl/wp-content/uploads/2019/10/Scientix-BRITEC-Citizen-Science-in-Schools-WEB-final-2.pdf

CS toolkit

The BRITEC Citizen Science Toolkit contains examples of various IT tools which could be used during the whole cycle of the creation and implementation of Citizen Science initiatives. In addition, it aims at providing a broader reflection on possible pathways for engaging schools and researchers in co-designing CS projects that serve the needs of both parties and looks to mobilise the support of other important stakeholders. Moreover, reflections on how to address research ethics and what the roles and responsibilities are of the actors involved in these types of projects, are also included as part of the report. Finally, the toolkit also provides relevant examples of useful sources and CS networking platforms developed under various Horizon 2020 projects.

The toolkit is available in English and four national languages (French, Greek, Polish and Spanish) on the project's website.

https://britec.igf.edu.pl/?page_id=407

Lesson plans

During the BRITEC project, nine Citizen Science lesson plans were developed in the pilot schools from four different European countries (three lesson plans were developed in Belgium, two in Greece, two in Poland and two in Spain), exploring their collaboration with scientific institutions and/ or researchers.

Here we zoom in on three of those lesson plans, prepared by BRITEC pilot teachers, which can be considered good examples of how collaboration between schools (students) and researchers enriches both research and learning processes and produces outstanding scientific and educational outputs. The first one showcases the potential and the benefits of Citizen Science activities for policy making, while the second raises young people's awareness of water management issues by involving them in hands-on activities including field trips, making scientific measurements and analysing the collected data. Finally, the third learning scenario involves students' collaboration with a researcher in analysing noise pollution and emphasises the importance of data quality, highlighting the teacher's role in the data-collection monitoring process.

Lesson plan "Analysis of students' dietary habits"[3], created in collaboration with researchers from the Aristoteleion University of Thessaloniki and teachers from Ellinogermaniki Agogi school in Greece, aims at addressing a current public health issue – child obesity. While the reasons why some children become obese are complex, their behaviour, influenced by many factors in the living environment (such as transport options, food advertisements, safety, food prices, etc.), is amongst the reasons most often mentioned by health professionals. Therefore, targeted at primary school students (aged 9 – 12), this lesson plan aims to explore children's behaviours and possible correlations between these behaviours and specific environmental parameters. To do so,

3 https://www.europeanschoolnetacademy.eu/assets/courseware/v1/28418c55eb6344393935d92fdf2374fe/asset-v1:BRITEC+Citizen Science+2021+type@asset+block/Dietary-habits_LS.docx

children are asked to become citizen scientists for four weeks, collecting data about their behavioural patterns and about the local environment using the myBigOapp.

Before starting with the data collection, students' weight and height are measured by the school's physical education teachers and they are asked to complete a small number of questions about their most common eating, physical activity and sleeping habits. After installing the application, the children start to take pictures of the meals they consume daily, and track their mood each time they upload a picture on the app. Moreover, students also take photos of food advertisements in their everyday environment (inside or outside school), regardless of the medium of advertising (brochure, billboard, poster on a bus, digital, online or on TV). Finally, children use smart watches to record GPS, physical activity and sleep data. In all the stages of data collection, they are instructed by their teachers and/or researchers. At the end, all these collected data are used to create complex statistical models to analyse if and how behaviour and the environment influence the prevalence of obesity. The gathered information becomes extremely beneficial for policy makers, allowing them to 1) predict how policy changes could influence obesity rates and compare different communities at group level and 2) develop and plan effective programmes and policies to reduce childhood obesity.

Lesson plan "Small retention is a big deal: Plants, water storage and drought inhibition (field activities by the river)"[4] was developed in collaboration between researchers from the Institute of Geophysics Polish Academy of Sciences and the Complex of Schools of Economics and Services named after Frederic Chopin in Żychlin. The programme, designed for students aged 15 to 20, aims to increase young people's awareness of issues about water management and the impact of seasonal changes of riparian vegetation and microclimatic conditions on water retention.

During field campaigns, students work in groups, carrying out tasks (each group has different tasks) listed on worksheets. The teacher observes the workflow and helps if necessary. As part of the activities, each group receives a topographic map of the area and marks the place where measurements will be taken as well as the direction of the river flow. Then, each group uses a GPS to determine the geographic coordinates of the measurement site. Based on knowledge and observation of the river, students enter information on the elements of the river valley (riverbed, river valley, floodplain) into worksheets. Following the instructions, they also measure the time taken by the float of plastics released into a river to cover the designated part of the river. They repeat the measurement five times. Then students calculate the arithmetic mean of the results obtained. This is how they measure the velocity of the river.

Another task is to perform simple meteorological measurements (air temperature, atmospheric pressure, cloud cover, wind direction) and compare these data with the data from the nearest weather station. By analysing the data, students learn about the microclimate of the river. Using their own knowledge and a key to designate plant species, students write the names of plants growing on the riverbanks. They also make photographic documentation of plants. Based on their observations, they describe the course of the river (water velocity, transported material, size of the riverbed, slope) and its morphological activity. They also report on the morphological forms created by the destructive or constructive activity of the river.

A summary of field activities takes place in the classroom during a scheduled class. Then the groups present their research. They do this in whichever form they wish – a description, a presentation, a film, a portfolio, etc. Each student is assessed. The final grade depends on the involvement of students in the field campaigns and the quality and presentation of the results of the work.

In addition to these activities, students are also asked to monitor seasonal changes of the riparian vegetation by taking photographs in a determined position and on regular basis. The frequency of observation will depend on the hydrological conditions of the specific place of observation. However, the minimum per month is recommended, and should not be less than once per season. The aim of this initiative is to learn how the seasons affect the river vegetation and

4 https://files.eun.org/SciEduDept/River-erosion-LS_MOOC.pdf

microclimate river conditions and to monitor the changes and provide data for further scientific analysis.

Lesson plan "Impact of traffic noise on people: Build your own disruption function"[5] created by Belgian teachers Bartel Willems and Wim Van Buggenhout in collaboration with researcher Dr Luc Dekoninck, is an example of how teachers can monitor the reliability of the collected data. With this lesson plan, secondary education students help the researcher to measure noise pollution in locations where Belgium has no monitoring yet, mainly on local roads. In the beginning of the implementation, the researcher explains the exact conditions that the students need to take into account before doing the measurements, so they are accurate and successful. More specifically, the measurements of noise exposure are conducted using a noise sensor placed in three different areas: at students' homes, in the industrial area of Londerzeel (a municipality in Belgium) and at the school. When it comes to the industrial zone of Londerzeel, four noise sensors are placed at varying distances (1m, 100m, 200m, 300m) from a busy highway. Since this activity is carried out within the school context, performing the noise measurements according to given guidelines is part of the students' assignment. Therefore, the quality of the data is assured by the fact that the measurements take place as part of STEM classes and under the close monitoring of the teacher.

MOOC

A unique **Massive Open Online Course (MOOC) "A Roadmap to Citizen Science Education"** developed by European Schoolnet with the support of all partners, focused on integrating scientific activities in STEM teaching by providing materials and stories of implementation from innovative Citizen Science education projects. Offered in English to teachers who are interested in bringing science into their class through designing, developing and implementing Citizen Science education projects, the MOOC ran on the European Schoolnet Academy,[6] a free online professional development platform for teachers and other education professionals. The course proposed a process of collaboration between teachers and researchers, providing insights from the perspective of researchers who have supported teachers developing STEM learning scenarios that include scientific activities based on the needs of active research projects. The main objective of the MOOC was to provide instructional design guidelines and the necessary resources so that teachers can develop a learning scenario of their own.

The course developed consists of four modules and includes a peer-review final activity. The objectives for each module are listed in *Table 1*.

Table 1: "A Roadmap to Citizen Science Education" MOOC: Modules and learning objectives

Objectives per module
Module 1: An Introduction to Citizen Science and Bringing Research into the Classroom • **Learn to tell the difference between Citizen Science as a volunteering process and Citizen Science as an educational activity within the school context; and define the stakeholders' roles.** • **Be introduced to Citizen Science activities in class and examples of Citizen Science projects.** • **Explore the main terms that need to be introduced in class when conducting Citizen Science activities.**

5 https://www.europeanschoolnetacademy.eu/assets/courseware/v1/e9d84a44742dd855db40b0a881b6428d/asset-v1:BRITEC+CitizenScience+2021+type@asset+block/BRITEC-Case-Study-Noise-review-ms-V02.pdf

6 http://www.europeanschoolnetacademy.eu/

Objectives per module

Module 2: How to Bring Citizen Science into Your Classroom

- Use examples of Citizen Science activities that were conducted in the classroom.
- Define the opportunities and implications that the introduction of scientific process in the classroom can have on the learning outcomes.
- Understand how to adjust scientists' professional practices so that Citizen Science Education activities can take place without compromising the teaching goals and procedures.

Module 3: Mainstreaming Innovation in Your Class

- Distinguish the main stages that are necessary to organise scientific collaboration in an effective way.
- Identify tools that can be used to mainstream innovation in the classroom and that are useful for Citizen Science projects.
- Identify and overcome potential ethical issues linked to the implementation of Citizen Science project in the classroom.

Module 4: Submit Your Citizen Science Learning Scenario

- Learn about different types of assessment.
- Finalise and submit your learning scenario.
- Exchange ideas with your peers and learn from their experience by giving and receiving feedback on your work.

https://www.europeanschoolnetacademy.eu/courses/course-v1:BRITEC+CitizenScience+2021/about

Pilot activities

Teachers

BRITEC piloting activities aiming at involving pilot schools in active collaboration with researchers took place during the 2019/2020 school year. Schools in Belgium, Greece, Poland and Spain implemented various CS-related activities (the creation of a lesson plan was one of them) proposed by scientists from local scientific institutions, who also offered their mentorship and actively assisted schools during the whole process. Before and after these activities, teachers and researchers participated in focus-group interviews, which made it possible to measure the baseline of knowledge and attitudes towards Citizen Science and its application within and outside of school contexts, as well as the impact on them resulting from their participation in the piloting activities.

The piloting activities also provided valuable information on participants' expectations and experiences in order to create guidelines for teachers and researchers on effective planning and conduct of similar activities in future, after the project's closure.

A total of 89 teachers from Spain, Greece, Poland and Belgium provided BRITEC with their feedback and insights before and after the implementation of their Citizen Science lesson plan in collaboration with a local university or research institute. Of these teachers, almost 70% had not participated in a Citizen Science project before but they were willing to involve one or two of their classes in the pilot. Before the implementation of the CS project, 65% of these teachers felt comfortable with the idea of using Citizen Science projects in their class, while 85% of them were confident that they were able to coordinate a CS project with their pupils. In terms of expectations, the teachers hoped that their involvement in a CS project would increase their students' motivation, would help them learn more about Citizen Science, and provide them with an opportunity to improve their project management and coordination skills (i.e., professional development). In addition, and when asked to consider anticipated obstacles, the lack of time and overall time management of the project came forward as the riskiest issues.

The post-implementation feedback showed that the participating teachers had indeed involved one or two of their classes in the project. 60% of these teachers, slightly less than the 65% of the pre-implementation results, felt comfortable using Citizen Science in their classes. A similar percentage, again less than the 85% that were originally reported, were actually capable of coordinating a Citizen Science project. In terms of outcomes, 70% agreed that pupils' motivation had increased, and they had also learned a lot about real science practices. As regards challenges, it was confirmed that lack of time was indeed a major issue. The organisation of communication with the researchers was reported as a major obstacle as well.

It is important to bear in mind that the piloting studies were implemented in full COVID times when teachers were suddenly forced to adapt to the remote schooling approach in a very short time. This resulted in highly increased stress levels among the teachers and might have influenced the evaluation results as well.

Researchers

Looking into the feedback collected from 20 researchers who participated in the BRITEC piloting activities, 45% had more than 15 years' experience in research and another 43% had been in research between 5 and 15 years. Before the start of the Citizen Science activities with schools, 65% of these researchers stated that they were comfortable with the idea of using pupils as "citizen scientists" in research projects and 82% were confident that pupils' contributions to research projects can support real research goals. In terms of outcomes, 65% were hoping to improve their communication skills and 62% were looking forward to the chance of interacting with people outside their usual professional circle.

After the completion of the Citizen Science activities, 83% of the researchers stated that they were comfortable with the idea of using pupils as "citizen scientists" in research projects and 85% were confident of the value of pupils' contributions to research projects. 85% had improved their communication skills and 92% had improved their organisational skills. Their expectations in terms of improving their skills (in the way they anticipated) were fulfilled for 82%

of the researchers while many of them stated that they enjoyed the interactions with teachers and pupils and the experience of converting from scientific to educational content. Maintaining pupils' motivation and organisation agreements with teachers was challenging for 68% of the researchers. While many researchers reported that pupils were interested and actively participated in piloting activities, others mentioned that the restrictions imposed by the pandemic made overall collaboration with teachers more complex and might have had an impact on pupils' engagement.

MOOC

272 teachers coming from more than 30 different countries completed "A Roadmap to Citizen Science Education" MOOC, taking place between 22 March 2021 and 28 April 2021. Participants in the online course (of whom the majority were female, aged 36 or older, teaching at primary and secondary schools in Europe and beyond), were provided with knowledge, insights and tools necessary for implementing a Citizen Science approach in classrooms of various STEM disciplines. Moreover, the course, comprising four modules, gave an introduction to a variety of possibilities and benefits related to contextualising scientific knowledge in classrooms when uniting efforts with scientists in CS practices. Finally, teachers and educators were encouraged to take an initial step towards the implementation of Citizen Science by developing their own learning scenario reflecting this scientific practice.

Evaluation method

The evaluation findings presented below are based on course registration and participation (started/completed) data, and on the data collected via two surveys completed voluntarily pre-course (n=155) and post-course (n=145), providing information about: the participants' profiles, impressions regarding the course and self-assessed knowledge of course topics. This method allowed us to measure the impact of the MOOC on teachers' knowledge regarding this scientific practice and eagerness to implement a Citizen Science approach in their teaching.

It is important to mention that 1054 teachers from 46 countries registered to take part in the MOOC, 502 participants started following at least one course module and 272 participants completed the MOOC. The participant was counted as a completer if she/he had explored all the sections of the MOOC and did all the activities.

Evaluation findings

Positive course impressions, leading to a wider uptake and implementation of a Citizen Science approach in STEM classrooms

When it comes to course impressions, 93% of participants reported that they found the course content particularly useful, rating the overall value of the course "Good" or "Very Good". Moreover, 85% of teachers who took part in the MOOC said that 1) they would recommend this course to a colleague (indicating that they "Agree" or "Strongly agree" with the statement) and 2) they will use the ideas and examples presented in the course in their everyday work ("Agree" or "Strongly agree"). Finally, 92% of participants indicated that the course made them more confident and able to implement Citizen Science in their classrooms ("Agree" or "Strongly agree").

As can be observed form the participants' responses, teachers and educators not only saw getting familiar with the Citizen Science practice as a valuable experience in exploring a less known pedagogical approach, but it also gave them more grounding and confidence to start or continue implementing it into their everyday teaching practices.

Positive change in educators' competences related to various Citizen Science topics

According to the survey findings, the number of participants who have "Good knowledge about the topic and feel ready to implement it in practice" increased by 17% after the course completion. Moreover, only 3% of participants reported having "Good knowledge and practice experience in the topic and feel[ing] able to advise/guide others" prior to the course compared with 23% who said so after completing it.

It appears that participation in “A Roadmap to Citizen Science Education” MOOC has greatly contributed to the development of teachers’ knowledge and competences regarding various aspects of Citizen Science implementation. Moreover, in many cases the expertise gathered during the course reached a sufficient level for teachers to be comfortable to share their knowledge on the adoption of Citizen Science in various STEM disciplines with their peers.

For policymakers

Establish government policies to support Citizen Science (CS)

Currently, governmental support to CS is provided sporadically and in unstructured ways, including research project management or the establishment of training programmes for scientists and educators. To capitalise on the benefits of CS-related activities, CS should be rooted in education and science innovation policies. Policies play a crucial role in enabling scientific innovation, since they facilitate and set objectives with regard to scientific and educational practices, while legitimising the ones that are related to these objectives. Moreover, policies define strategies for achieving the formulated objectives. These strategies are presented in the form of plans and programmes, which result in real actions – projects, initiatives, campaigns, etc. All these concrete actions can only be realised when specific funds are granted. Thus, it is vital for CS to be anchored in education and science innovation policies to be considered legitimate, acknowledged as valuable scientific practice, and granted means to materialise. At the same time, it is important to monitor and guide CS. Although Citizen Science brings various benefits for both scientists and citizens, these benefits are only realised if the methods used during CS activities are of good scientific quality.

Legitimisation: acknowledge the value and contribution of CS

Education and science innovation policies should acknowledge Citizen Science as a legitimate form of scientific practice. In this way, the contribution of CS to scientific and social innovation will be underlined and associated with the human right to science. The right to science was established in the framework of human rights, as the "right to share in scientific advancement and its benefits" (Art. 27 in UN 1948).[7] Until recently, this right was mainly understood as the right to access information and gain knowledge as well as the right to benefit from different scientific achievements. Lately, this understanding has evolved "from the right to access information and knowledge to the right to participate" (De Marchi et al. 2001).[8] As a result, education and science innovation policies should re-assess the very definition of scientific practice in the light of human rights, highlighting those granting this right to the citizens.

Moreover, education and science innovation policies should reflect the major opportunities and various benefits to science *per se* that arise from the public's participation in scientific activities. These include the new forms of knowledge[9] generated through knowledge exchange between citizens and scientists; improvement of data and scientific methodologies (which go beyond traditional scientific practices); increased scientific capacities in societies; the strengthening of co-responsibility and trust among all parties involved; the understanding of cooperation to find solutions to certain problems. In summary, the acknowledgement of various benefits brought by Citizen Science practice would be of advantage to both the scientific community and the public.

Recognition: Highlight and showcase good examples of CS and their impact on society

With regard to solving issues related to local or broader societal contexts, we also suggest that education and science innovation policies emphasise the role of science and education in addressing urgent societal challenges and highlight the good practices of Citizen Science as well as their positive impact on society or, in other words, their contribution to social innovation in a broader societal context than the scientific and educational benefits. Various CS projects carried out in cooperation with researchers and the public collect enormous amounts of information and lead to valuable findings regarding local/national issues. An example could be the Belgian BRITEC piloting study where citizen scientists using their smartphones monitor noise pollution (which can cause increased stress, cognitive impairment and illness in humans, decreased fitness and altered behaviour in wildlife) in urban or protected areas. This project serves as an illustrative case of how, collaborating with citizens using inexpensive

7 UN (United Nations). (1948). Universal declaration of human rights. Retrieved from: https://www.un.org/en/about-us/universal-declaration-of-human-rights

8 De Marchi, B., Funtowicz, S., & Guimarães-Pereira, A. (2001). From the right to be informed to the right to participate: Responding to the evolution of European legislation with ICT. International Journal of Environment and Pollution, 15(1), 1–21.

9 Violet Soen & Tine Huyse (eds.) (2016). *Citizen Science in Flanders: Can We Count on You?* [Young Academy position papers – no. 2]. Retrieved from http://jongeacademie.be/standpunt-citizen-science/

sound measuring apps, scientists can collect vast amounts of data and come up with findings related to an issue of public concern which can, consequently, be addressed by policy makers.

Funding

Besides legitimising Citizen Science as a scientific practice and acknowledging its scientific and societal value, stable funding structures are needed to bring CS to its full potential. For this reason, it is essential to allocate budget to CS but also to re-assess current budgets allocated for education, research and innovation, taking into account possible synergies with CS that can emerge. This is especially important considering the particularities of CS projects, which include more management and communication efforts and flexible timelines. CS project timelines are particularly fragile since it takes time to manage, instruct and maintain communication with students or citizens who must usually build their experience in terms of scientific investigation. Moreover, in CS projects, participants tend to collect vast amounts of data which can entail lengthy processes of synthesising, analysing and drawing conclusions from it. In addition, education and science innovation policies should identify resources needed to invest in providing innovative pedagogies and training. Scientists and educators are hesitant to engage in CS activities not only because they require increased efforts and resources but also because there is a lack of knowledge and of training programmes promoting such activities. Finally, specific funding structures are needed to overcome bias and prejudices held by the public regarding Citizen Science being a practice used to reduce research costs (since citizens or students usually participate voluntarily). In many cases, CS projects require even more resources, expertise and time compared with traditional scientific projects; however, they usually result in win-win situations, with benefits for all parties involved.

Establish CS monitoring and guidance mechanisms

While in our view it is vital for Citizen Science to be recognised and acknowledged as a scientific practice bringing various benefits, it is also important to keep in mind that these benefits only materialise if the methods used during CS activities are of good scientific quality. Otherwise, there is a risk of diluting the scientific and educational value of CS activities. Decision makers should be fully aware of this and establish appropriate monitoring and guidance mechanisms to ensure the quality indicators of the CS projects/activities according to which they would be monitored. These monitoring and guidance tools should involve but not be limited to the quality of the data collected, the competence of the researchers running the project, the overall project implementation structure and plan, the actuality of the issue/topic explored and its contribution to scientific exploration. Finally, the potential of a project/activity to be replicated or upscaled should also be taken into consideration to ensure continuity of the activities in the project's afterlife phase. An EU-level observatory might also be considered in a long run.

Include CS in the policy-making cycle

Policymakers can use CS projects at different stages of the policy-making cycle in order to obtain targeted data that can help them take informed and data-driven decisions. CS can provide valuable contributions to policy anticipation (agenda setting) or be used as a source of information gathering. An example[10] of such close collaboration can be seen in a municipality that wants to address the issue of littering. A CS project can help the municipality collect information on the areas that particularly suffer from litter and provide insights on the type of littering that is occurring i.e., plastic bottles, tobacco waste, food wrappers, grocery bags, etc. Based on this information, the municipal council can decide on specific actions e.g., awareness campaigns targeting specific audiences and age groups, putting more bins (of a certain type) in specific areas, putting bigger bins and recycle bins in other areas, etc. Moreover, CS can also be recognised as an important tool for supporting the policy cycle. As an example, we can consider IAS (Invasive Alien Species) CS projects. Invasive Alien Species are a growing threat to Europe's biodiversity. Participants of different CS projects provide useful input to the consideration of species for inclusion in the list of IAS of Union concern

10 Authors' idea, inspired by: https://www.nature.com/articles/s41598-020-74768-5

of the IAS Regulation.[11] When it comes to policy implementation, CS projects can significantly expand the spatial and temporal scale of the data produced, which in conventional science practices would not be achievable. New geo-referenced IAS occurrences can be submitted swiftly and directly from the field, which is highly suitable for early warning mechanisms. Therefore, CS provides data which complement the official Member State surveillance in detecting the occurrence of a new IAS. At the same time, CS reduces the administrative burden, management and communication efforts of the national authorities. Some CS projects allow users to deploy specific tools for managing IAS (e.g., EEIKO[12]). In this way, CS participants contribute to policy evaluation as well.

Foster the creation of an online community for teachers, researchers, policy makers and company representatives

Desk research clearly indicates that many Citizen Science projects of various topics and levels of complexity have been carried out or are still under way at European and national level. But what happens at the end of these projects? Is it possible to gain access to their results and outcomes? How can someone get in touch with their creators and learn from their experience? Efforts to create repositories and communities of Citizen Science practitioners, although somewhat fragmented, have been made by European projects,[13] universities[14] and other organisations.[15] To support, complement and consolidate their efforts, the creation of a dedicated platform that would aggregate the various available repositories and provide smart metadata and search functionalities is suggested. In addition, the creation and animation of online communities per topic, language, or country/area, would also contribute to the dissemination of good practices and the initiation of new partnerships at both national and European levels. Universities and research institutes, companies and local authorities also have a role to play in the platform since they can share ideas on possible CS projects that relate to local issues and needs. Through such a platform, teachers and schools would have the opportunity to learn from experienced schools, communicate with various stakeholders and explore project ideas in their areas. Moreover, all projects should be encouraged to provide their results as Open Educational Resources with open licenses and open access, since this will also support the sustainability of the CS projects.

During the focus-group interview for teachers organised in Poland, participants also expressed a very strong interest in getting access to a collaboration platform at national level, where they could find opportunities to collaborate with researchers and scientific institutions. Such a platform could offer researchers a virtual space where they could announce new requests for collaboration with schools and/or local communities and offer training and support. It would give visibility to relatively small CS initiatives, facilitate coordination of CS actions and foster identification of potential participants. Although such initiatives exist at a European level, national collaboration would be highly appreciated for the reasons stated. A good example of such a platform is the Observatory of Citizen Science in Spain and the Web portal ciencia-ciudadana.es, which are the result of a project developed by the Ibercivis Foundation in collaboration with the Spanish Foundation for Science and Technology (FECYT)-Ministry of Science and Innovation.

Foster collaboration with private sector companies

Collaboration with industry and the private sector can enrich and boost the organisation of Citizen Science projects and activities. Such projects offer deeper collaboration opportunities with different actors and connection to real-life problems and their possible solutions, while they provide pupils with information on possible STEM careers. Projects of this type can promote reusability, accelerated innovation and exploitation of more openly accessible research data for a range of

11 Invasive Alien Species (IAS) are animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment. They represent a major threat to native plants and animals in Europe, causing damage worth billions of euros to the European economy every year. As invasive alien species do not respect borders, coordinated action at the European level will be more effective than individual actions at the Member State level. More information: https://ec.europa.eu/environment/nature/invasivealien/index_en.htm

12 EEIKO Plantas Invasoras is a multiplatform application enabling a global vision of the spatial distribution of invasive alien flora species. EEIKO records are based on citizens' participation. The application also provides management tools to IAS managers of environmental authorities, to tackle invasive species. More information: https://www2.eeiko.es

13 https://eu-citizen.science

14 https://www.zooniverse.org/

15 https://scistarter.org/

purposes, including their ethical commercial use. For example, Safecast[16] was founded after the Fukushima disaster in Japan in 2013 where concerned citizens collected data on the spread of harmful radiation in the region. Since then, working in collaboration with the private sector,[17] Safecast has grown into a global Citizen Science network across 100 countries collecting more than 60,000 daily measurements of environmental data (not just radiation) and most recently data related to COVID-19. In addition to data, Safecast also exemplifies citizen initiatives to design and fabricate scientific hardware and release it as open-source hardware.

For scientific institutions

Most of the science communication initiated by universities is unidirectional and focused on informing the public about current scientific findings and achievements. Scientific institutions should gradually transition to two-way communication activities, which involve direct exchanges with students and the public including open debates or lectures organised by scientific institutions and involving students and the public in various stages of research by capitalising on the advantages of CS projects. These actions may transcend the usual science communication activities and transform them into research tools.

Support CS projects that go beyond data collection

To close the gap between scientists and the public and to open the door for two-way scientific and scholarly practice, involving not only scientists but also students and citizens, universities and research institutes should support the development of CS projects of various engagement levels but also opt for CS projects that go beyond simple data collection and engage their participants in more complex collaboration, like processing the data and sharing the research results or even influencing the choice of research method and taking part in setting the research agenda.

According to the pyramid classification proposed by Bonney at al. (2009),18 there are four main types (levels) of citizen involvement in CS practices (CS projects). The lowest part of the pyramid refers to "minimal involvement" or projects where only minimal efforts are expected from participants in terms of scientific and scholarly practice. Usually, in these projects participants are expected simply to collect the data (often using their mobile phones or other online tools) and pass it on to scientists. The second level refers to the "contributory" approach, where both scientists and the public contribute to and learn from the research process. An example here could be a project where participants are asked to record the songs of different birds in their garden and then classify them according to a given typology. In this way, participants not only collect scientific data which will later be given to scientists to analyse but also learn how to classify certain types of birds. Another example of this type could be the "SPIN-CITY"19 project by the University of Ghent which asked citizens to take photos of spiders and upload them to a dedicated portal, providing additional details. This was part of a research study investigating the impact of heat stress on the city's animal population. By participating in the research, participants not only collected data but also learned to differentiate male and female spiders. The third level of the pyramid classification proposed by Bonney et al. refers to "collaborative" involvement, where the public participates in various stages of the research. For instance, citizens may generate and even present the research results. History-oriented CS projects that involve participants in transcribing historical documents and presenting their findings fall under this category. As an example, we can consider the Velehanden.nl20 platform which contains a treasure of cultural-heritage-related Citizen Science projects, with 20,000 volunteers subscribed to the platform. One of these projects is "S.O.S. Antwerpen",21 a project of the Belgian University of Antwerp, in which volunteers transcribe information about the causes of death of Antwerp civilians between 1820 and 1946. At the top of the pyramid classification are "co-creation"

16 https://safecast.org/, an international volunteer organisation
17 https://bit.ly/3lvHcZq
18 https://academic.oup.com/bioscience/article/59/11/977/251421
19 SPIN CITY is a Citizen Science project run by the University of Ghent. More information: https://www.spiderspotter.com/en/info/spin-city
20 https://velehanden.nl
21 https://sosantwerpen.be/project/

projects, which apply the equal footing approach; in other words, these are projects where scientists and participants work together as equal partners. Citizens/students together with scientists may define the research agenda and methods, choose research instruments, conduct the analysis, present the results, etc. The "Gentenair"22 project can be taken as an illustrative example here. A bottom-up CS initiative taken by local concerned citizens and environmental activists (in collaboration with scientists) provided information about how to build (or choose) your own sensor for measuring particulate matter and also referred to other DIY initiatives showing how to measure other aspects of air quality. Referring to the aforementioned pyramid classification, scientific institutions are encouraged to make a deliberate choice when considering which level of participation to adopt in a CS project, since all of them can serve different parts of a CS project (some projects have a larger focus on the scientific benefits, other projects have larger focus points on the educational or societal benefits). Nevertheless, it is important to notice that when it comes to educational benefits, CS projects that go beyond data collection, connect to a local issue and offer real research opportunities, i.e., analysing data, making and testing a hypothesis, etc. are more attractive to schools and students. Such projects have the potential to lead to long-term collaboration and impact students' perceptions of science and its role in society as well. Since CS projects applying a collaborative or equal footing approach are less common than those requiring "minimal involvement", it is also recommended for scientific institutions to consider organising related training, especially for PhD students or early-stage researchers who might be more eager to experiment with different methods and explore various scientific and scholarly practices.

Connect CS projects to the local community

CS projects that focus on solving existing local societal or environmental issues often have a larger overall impact on society than other projects. They respond to a pressing issue and involve a variety of stakeholders and therefore have the potential to gain a larger societal support base. We encourage scientific institutions to explore and support projects that focus on solving real local issues, and hence strengthen their relationship with the local community. The CS project mentioned earlier involving the collection of information on the different types of littering sources and the places where the problem is most observed will result in tangible actions and solutions from the municipality. Such a CS project will contribute to social innovation by involving different parties who work together towards a common goal and strengthen the sense of co-responsibility between citizens, students and policy-making bodies. Moreover, stakeholders will be more eager to participate and provide accurate results since the CS project outcomes are directly related to their environment and quality of life, given that they are provided with reliable protocols to carry out the research (otherwise, there is a risk that knowing that the project outcomes will influence their daily lives, participants may adversely try to influence their observations and analyses). An illustrative example is CrowdWater,[23] a CS project run by the University of Zurich, Department of Geography, Unit Hydrology & Climate. CrowdWater invites the public to use the CrowdWater app to collect hydrological data. The long-term goal of the project is to collect many observations and thus improve the prediction of hydrological events such as droughts or floods. Moreover, the project investigates how the public can be involved in the collection of hydrological data, as well as what value the collected data can have for hydrological forecasts.

Include original and authentic CS projects

Most CS projects from all over the globe mainly investigate topics of natural sciences (mostly these include Environmental Sciences, Astronomy, Marine Biology, Biology, etc.) and a significantly smaller number of CS projects explore topics in humanities or social sciences. Therefore, scientific institutions are invited to promote the CS approach in their humanities and health departments and explore its potential benefits for research topics that have not yet involved CS. One example of a quite original CS project is the Happiness Project[24] run by (among others) Robb Rutledge, who is a

22 https://gentenair.be/

23 CrowdWater is a project investigating how the public can be involved in the collection of hydrological data, as well as what value the collected data can have for hydrological forecasts. More information: https://crowdwater.ch/en/

24 The Happiness project is a citizen science project run by neuroscientist Robb Rutledge. More information: https://rutledgelab.org/

neuroscientist at University College London. Participants are requested to download a mobile app, play different online games and fill out surveys to find out the causes of happiness. With every game they play, participants generate data that will be used in scientific research with the goal of constructing a mathematical model that explains how people make decisions, describes the factors that determine happiness and deciphers the relationship between happiness and the decisions we make. Ultimately, this will help the researchers to better understand the processes linked to mental health problems such as anxiety and depression to enable new treatments.

For schools

With Europe's shortage of STEM-skilled labour force, there is a real need for innovative approaches to demystify science and increase the motivation of pupils towards STEM subjects. By introducing the Citizen Science approach in classrooms of scientific – and other – disciplines, teachers and educators will not only engage pupils in research practice but also increase their motivation to pursue scientific careers. Therefore, school managers are encouraged to support teachers' and students' involvement in CS projects. An initial step can be the introduction of CS to STEM teachers by showcasing best practices of schools' involvement in CS projects and by putting them in touch with teachers or communities of teachers who have already implemented CS activities.

Furthermore, the role of the teacher as a changemaker should be considered. Teachers are prominent in bringing innovation to schools. Their competence in creating a positive and enriching learning environment correlates positively with students' learning achievements and with their engagement in the subject. Therefore, we recommend that schools offer STEM teachers training in the implementation of CS projects. These training events may also be organised in collaboration with scientific institutions which have run CS projects or other schools that have already participated in a CS practice. CS projects can also be viewed as a way to introduce and bring students closer to STEM careers. Considering all these parameters, it is essential for teachers to have the opportunity to be acquainted with innovative pedagogies and approaches (including CS), understand their benefits, recognise their value and implement them in their classroom.

Recognition and support of CS by school leaders

In our view, it is vital that CS activities are recognised and encouraged by head teachers and school management. It is problematic for teachers to be driving forces or to take the initiative to build or participate in a CS project without being properly supported by their schools. It would help teachers tremendously if they would got support from their head teacher, be it practical, financial or moral. In some cases, teachers have quite a lot of administration and negotiation to do if they want to engage in activity that could cost even a minor amount of money or when they want to join a project that is not run by the school itself. School leadership's support would facilitate teachers' participation in CS and, in many cases, reduce the administrative burden as well as time spent explaining how participation in a certain CS project is worth the teacher's and his/her pupils' time. Moreover, being aware of CS as a valuable and innovative practice that is readily combined with innovative pedagogies, head teachers would be more eager to provide CS-related training so the whole school is acquainted with this approach and not only the enthusiasts.

Importance of good and close collaboration with CS partners

As mentioned before, it is important for schools to establish connections with scientific institutions and researchers and actively engage in discussions, resulting in developing CS practices that are advantageous to both scientists and educators. Therefore, we recommend that schools be active in seeking out connections with scientific institutions and even initiating the CS project idea, asking universities or research institutes to collaborate. Moreover, it is important that schools actively follow the research activities of their partner universities. In this way, schools will stay on touch with what is happening in research and be able to spot in good time the possibilities for collaboration regarding the investigation of topic, applying CS practice. In addition, schools should reflect on any other partner that might be able or interested to collaborate. This could even concern private companies producing some tools that can be part of a test kit in a CS project, on condition that the project adopts clear protocols to avoid conflicts of interest.

Aim for a win-win situation

Citizen Science projects should create win-win situations to all parties involved. Therefore, schools should reflect on what they wish to gain from collaboration with scientists. Will their pupils learn new skills on how to apply new research methods? Will they improve their knowledge regarding certain societal issues/ real-world problems and the ways to solve them? Will students be introduced to interesting STEM careers? Maybe by participating in a CS project students will develop their interest towards a particular research subject? Will they develop their 21st-century skills such as critical thinking, creativity, collaboration, communication, information, and data literacy?

At the same time, the scientific institutions should have an opportunity to express and openly discuss with their school partner what they expect to achieve via this collaboration. Do they want to collect large amounts of data? Do they wish to develop their scientists' communication and presentation skills? Do they want to publicly communicate about their work? Maybe they wish to attract young people to their department and line of research?

Expressing and openly discussing both parties' aspirations well in advance, contributes to a deeper understanding of all stakeholders' needs, creates a collaborative and respectful environment and lays the foundations for long-term collaboration.

Start small, aim high!

For newcomers to Citizen Science, the choice of their very first project can be a nerve-wracking experience. Schools and teachers who have been through this process agree on the importance of starting with something simple and small to build teachers' and students' confidence, competencies and understanding of the range of CS projects and activities. Projects like "Globe at Night"[25] that raise awareness of light pollution and its impact on communities can be a good starting point. Students can record and report their night sky brightness observations daily. All they need is a computer or phone. This activity can be a great supplemental learning experience to a broader CS project on light pollution or be used as a standalone introductory activity.

Use CS as a way to enhance specific pedagogies

By providing examples of real-world problems and raising certain questions to students, all combined with innovative pedagogical approaches like Inquiry-Based Science Education (IBSE), Project-Based Learning (PBL) or Place-Based Education (PBE), their creativity and curiosity in relation to scientific research is activated. While projects requiring "minimal involvement" of participants as described by Bonnie et al. (2009) may provide only limited space for fostering IBSE, PBL or PBE, those based on equal footing or the "co-creation" approach can benefit significantly when combined with the pedagogies mentioned.

Citizen Science and IBSE (Inquiry-Based Science Education)

CS projects offer opportunities for applying Inquiry-Based Science Education,[26] especially those involving citizens (students) as collaborators. These are the projects where students are not only collecting data (which is already a valuable scientific practice in itself) but also actively engaged in setting the research agenda, designing the research methodology and even analysing results. The direct contact with scientists in the various stages of such projects gives students the opportunity to explore "hands on", to experiment, to ask questions directly and to develop responses based on the collected data and reasoning. By participating in CS projects (especially those requiring collaborative involvement) students are engaged in a very dynamic and constantly changing scientific process which stimulates their curiosity. Moreover, by participating in various stages of CS projects, students gain a wider picture of the scientific approach with regard to the object of investigation. Consequently, participants of CS projects become

25 https://www.globeatnight.org/

26 Inquiry-Based Science Education (IBSE) for students can be expressed in terms of the process and outcomes of learning about the world around them. It is a process of developing understanding which takes account of the way in which students learn best, that is, through their own physical and mental activity. It is based on recognition that ideas are only understood, as opposed to being superficially known, if they are constructed by students through their own thinking about their experiences. More information: https://www.interacademies.org/education/ibse

learners who pose thoughtful questions, make sense of collected information and develop new thoughts and ideas about a science topic and the world around them. Finally, through inquiry learning, CS participants develop the skills and attitudes needed to be successful and independent learners and citizens.

Citizen Science and Project-Based Learning

Since CS projects focus on real-life matters and investigate them for an extended period of time, they also open up opportunities for enhancing Project-Based Learning. Like IBSE, this pedagogy can enhance CS projects applying a collaborative or equal footing participatory approach, allowing students to be actively engaged in different stages of research. Moreover, CS projects are perfect for applying PBL since they involve different stakeholders and often more than one scientific discipline. In this way, pupils learn that real-world research is rarely based on information or skills from a single subject area and different stakeholders have a different role to play throughout the project. Furthermore, and especially by participating in CS projects addressing local issues, pupils learn to engage in inquiry, consider different solutions and come up with a proposal which will help address the issue or challenge that is presented. Lastly, the PBL pedagogy implies fostering the 21st-century skills, including collaboration, critical thinking and presentation skills, that students need in order to succeed in today’s world.

Citizen Science and Place-Based Education

Since Citizen Science projects are often implemented in the vicinity of schools or homes, they are good examples of Place-Based Education (PBE). PBE focuses on local heritage, cultures, landscapes, opportunities and experiences. It emphasises learning through participation in service projects for the local school and/or community. In PBE, learning takes place on-site in the school yard and/or the local environment, focuses on local themes, systems and content and should be personally relevant to the learner. In many Citizen Science pilots implemented within the BRITEC project, all the above-mentioned assumptions were fulfilled. PBE also serves as the basis for understanding and engaging in regional and global issues, by starting from local content and then extending it further.

Involve students in the design and selection of the CS project

When it comes to schools choosing a Citizen Science project to participate in, students’ involvement in the process will help them develop their reasoning and presentation skills but it will also increase their ownership of and engagement in the upcoming CS projects. Teachers and educators may present students with a list of suggested CS projects put together by the school and the university partners, and students can be invited to debate and come up with their final selection. In this way, identifying the most relevant CS to participate in becomes a creative, participative and democratic process.

Moving forward...

As already stated in previous sections of this publication, Citizen Science offers a variety of opportunities not only for scientific but also for social advancements. To fully capitalise on the potential of this scientific practice and to create favourable conditions for it to further develop and contribute to the role of STEM in providing solutions and ways forward for real-life problems/challenges, first and foremost, acknowledgement and recognition at the policy level are needed. As was mentioned in the start of this publication, besides acknowledgement of its value and benefits to both science and society, it is important that Citizen Science is anchored in education and science policies, and as such gets the means for concretisation. Moreover, looking at some successful examples, it is evident that CS can largely and directly contribute to any step-in policy-making processes/cycles, and hence cannot be ignored, and should be further explored and nourished as a magnificent potential tool for enhancing data-driven policy making.

Furthermore, it is important that both the public and academia are fully aware of both the benefits that Citizen Science initiatives provide to society and the importance of citizens' active participation in scientific research. Therefore, scientific institutions should urgently shift from one-way to two-way communication, focusing on direct exchanges with students and the public by involving them in various stages of the research. The bottom-up involvement approach, allowing participating citizens not only to collect data but also to contribute to the different/later stages of the research such as data interpretation, analysis and presentation should also be considered the direction to take in order to bring the most educational benefits. In addition to the various CS initiatives, CS projects that directly connect to a real-life local/national/global issue are to be supported in order to fully contribute to societal innovation and to have a positive impact on citizens' perceptions of science and its role in society.

Moreover, for educational outcomes to be achieved, schools should opt for **introducing** the Citizen Science approach in classrooms of scientific and also other disciplines. In this way, teachers and educators will not only engage pupils in research practice but also increase their motivation to pursue scientific careers. It should also be acknowledged at the school level that CS activities not only spark and cultivate scientific curiosity but also contribute strongly to fostering innovative pedagogies such as Inquiry-Based Science Education (IBSE), Project-Based Learning (PBL), Place-Based Education (PBE) and the 21st-century skills needed for life-long learning. Finally, it is important to fully appreciate teachers as changemakers and, therefore, provide teachers and other educators with continuous practical support as well as training on the introduction to and ways of bringing CS into classrooms of various subjects. This training might be organised in collaboration with (local) universities and research institutes, resulting in long-lasting and productive relationships between the two.

BRITEC
BRINGING RESEARCH INTO THE CLASSROOM

Co-funded by the Erasmus+ Programme of the European Union

The work presented in this document is supported by the European Commission's Erasmus + programme – project BRITEC, coordinated by the Institute of Geophysics, PAS. The content of the document is the sole responsibility of the organizer and it does not represent the opinion of the European Commission (EC), and the EC is not responsible for any use that might be made of information contained.

Institute of Geophysics Polish Academy of Sciences
UAM Universidad Autónoma de Madrid
GFOSS Open Technologies Alliance
ibercivis
European Schoolnet
KU LEUVEN