COST Action CA15212
Citizen Science to promote creativity,
scientific literacy, and innovation throughout Europe

Training needs and recommendations for Citizen Science participants, facilitators and designers

Research report from COST WG2 workshop - Systematic review on training requirements and recommendations for Citizen Science
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1. Introduction

Citizen science (CS) as a collaborative effort of citizens and scientists in producing new scientific knowledge has opened up an increasingly popular path of scientific research and practice (Storksdieck et al. 2016). Citizen Science programmes can pursue a combination of scientific goals of data collection and analysis with formal and informal science education goals, public engagement goals as well as environmental justice and conservation goals.

With the great potential of citizen science projects, citizen science has impressively grown in multitude over the past decade. Such projects come in many shapes and forms, ranging from online projects, global or wide-area ones, through to local and community-level projects. This huge range of formats and scope, as well as the inherently integrative nature of citizen science, poses challenges for the design, administration and operation of citizen science projects. These include but are not limited to the production of reliable, scientifically acceptable data, a much-debated issue (Aceves-Bueno et al., 2017; Bonney et al., 2014; MacKenzie et al., 2017) for which several solutions have been proposed (Freitag et al., 2016; Kosmala et al., 2016). Equally challenging is the simultaneous integration of scientific, educational and engagement goals, which sometimes go as far as changing values, attitudes and identity, or inducing behavioural change and inspiring active citizenship (Price & Lee, 2013; Ballard et al. 2017).

Much of the difficulties in overcoming these challenges stem from the engagement of project designers, facilitators and participants in tasks and practices that they were usually never formally trained to perform. For example, non-scientists may not have the knowledge required to carry out accurate data collection, likewise, scientists may not be versed in volunteer recruitment and communication. It is, therefore, a recommended procedure to develop training sessions that support the designers, facilitators and participants of citizen science while ensuring that all desired outcomes are satisfactorily accomplished. Providing such training could help obtain the required scientific outcomes while improving participants' scientific competence and increasing awareness of the issue at hand.

However, how to best design these training sessions, what the training requirements are and what topics need to be addressed, in various and diverse projects, is not yet fully understood. Such questions were the main concerns of the COST workshop "Systematic review on training requirements and recommendations for citizen science" that hosted a group of experienced designers and facilitators of citizen science projects. The results and conclusions of our discussions, presented in this report, attempt to provide a generalized answer to these questions, taking into consideration the many

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types of citizen science projects, and the many different ways to design them as best as we could.

1.1. Training in Citizen Science projects

The Cambridge dictionary defines training as: “the process of learning the skills you need to do a particular job or activity”. In accordance with this definition, we refer to “training” here as the action of teaching skills and/or knowledge required to develop a competence related to a specific task/activity of a CS project. While training goals are generally related to the scientific process that generates new knowledge, it can also be combined with educational and/or societal goals. Training can be done face-to-face by project facilitators or online using tutorials, videos, games or text documents. For some practical tips about facilitating citizen science-related training, we recommend Ballard & Harris (2019).

1.1.1. Training audiences

When approaching the development of a training plan or training resources for a Citizen Science project, it is important to consider the needs of the potential audiences. While the majority of CS projects have some resources for training participants, the need of training for other groups has been largely overlooked (Tweddle et al. 2012; Shirk and Bonney, 2015). In this report, we identify three key audiences of CS project training and define these groups as:

Participants - People who take part in citizen science projects and contribute to the project with different levels of involvement (data collection, classification, defining research questions etc.). Can include the general public, students etc.

Facilitators - People who train or educate participants in a citizen science project, or lead groups of participants. Can include scientists, teachers, nature guides, museum educators etc.

Project designers - People who initiate and design citizen science projects. Can include scientists, engagement professionals, project coordinators, NGOs or interested citizens.

It is recognised that individuals may occupy more than one of these roles in any CS project, and may move between roles as a project progresses or their involvement evolves.

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2. Workshop objective and report structure

The objective of the workshop was to understand what the **training requirements** for project designers, facilitators and participants are, and **to use case studies** (e.g. participating in OPAL facilitator training or the Pedagogical Sailboat training approach) to develop recommendations for designing and running future citizen science training for the three target audiences we identified - designers, facilitators and participants (see section 1.1.1- training audiences).

Based on a knowledge exchange of our previous experience in the field of citizen science in general and citizen science training, in particular, the workshop participants discussed the training requirements, in the form of needs and challenges, for each target audience. We systematically structured the needs and challenges of these groups starting with participants and building towards facilitators and designers. We first defined what participants may need to be enabled to fully participate in the project. Based on the participants' needs, we developed ideas for what facilitators need in order to train the participants accordingly. Similarly, the training needs of citizen science project designers were based on the needs of facilitators and participants in addition to general considerations of what might be helpful when designing a citizen science project. The results of this first part of the workshop can be found in section 3 - training needs. After clarifying the training needs and challenges, we pooled our experiences to develop training recommendations to address the needs and challenges identified for each target audience (section 5 - training recommendations) and referred to already existing resources that could be used to address certain needs or examples of existing training materials.

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3. Training Needs

The next section outlines the training needs of the different audiences within Citizen Science projects. Firstly, we discuss training needs around participant involvement as this is relevant to three training audiences. Secondly, we focus on the specific training needs for each of the target audiences.

The needs are divided into three broad categories: Core, Operational and Engagement. The '**Core'** needs are those related to the holistic and epistemological nature of the project. The questions of 'why should I do this?' and 'why is this important?' will be considered here. The '**Operational'** needs are concerned with training related to the project processes. The practical and organisational aspects of the project will be addressed in this section. The '**Engagement'** needs section is concerned with training related to the experiential needs of those involved in the project. A summary of the needs in all three categories is provided in table 1.

3.1. Core Needs

The core needs are concerned with the holistic and epistemological nature of the project, information about the project which should be clear to all involved and therefore, need to be addressed in every training activity or event. This section will consider the reasons and importance of participating in the citizen science project. The following needs were identified for project participants, yet are important to consider for all training audiences.

1. **Provision of a clear definition of Citizen Science** - Understanding the nature of Citizen Science as a collaboration between individuals/local communities and the scientific community.

2. **Clear delivery of scientific background of the project** - Understanding the scientific background, concepts and skills that are involved in the project.

3. **Relevance of project to the training audience** - Understanding the local and global relevance of the project and relating it to participants' particular contexts, needs and interests.

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Table 1. Summary of participants, facilitators and designers training needs in citizen science

	Definition	Participants	Facilitators	Designers
Core	Holistic and epistemological nature of the project, e.g. 'why should I participate?' 'why is this important?	Citizen Science Definition		
		Scientific background of the project		Define scientific topic and background
		Local and global relevance	Curricular and pedagogical relevance	Research relevance, impact and limitations
Operational	Practical and organisational aspects of the project and project processes	Project design rationale		Project design strategies
		Data and technical practice	Data and technical protocols facilitation	Data and technical protocols design
		Platform introduction and practice	Platform facilitation	Platform design
			Lesson plans, teaching methods	
Engagement	Personal and experiential needs of those involved in the project	Recruitment opportunities		Recruitment and retention strategy
		Enjoyment	Enjoyment facilitation	
		Communicating with the project team	Communicating with participants	
		Recognition	Recognising achievement	Building in recognition
		Wider Engagement opportunities	Participant management	Connecting to the wider CS community

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Additional audience-specific considerations

When discussing the above needs some elements may be similar between audiences, while others may differ. For example, the relevance of the project could be similar to different people when discussing conservation outcomes, but different when discussing local hazards. The different perspectives and motivations of different participants and training audiences may impact their appreciation of the project's background and relevance in their particular circumstances (O'brien et al., 2008).

In developing training for project facilitators, the scientific background of the project must be delivered in a way that will give facilitators confidence in articulating the information to the project participants. There is also a need to relate to particular curricular or pedagogical concepts that are relevant to the training audience.

When developing training for project designers, the needs described above are important factors to articulate and demonstrate. Project designers will need to make decisions about their project design, define project goals and methodologies and consider the relevance of the project for the scientific field, the community and the participants. As such, they need to understand core needs and make a conscious decision about whether a citizen science approach is the right match for their chosen scientific purpose.

3.2. Operational Needs

The operational needs are concerned with the practical and organizational aspects of a project which should be clearly defined in any training activity or event. The following needs are important to consider for all training audiences.

1. **Explanation of project design** - Understanding the nature of the project design and the reasoning behind its accurate implementation. This is of increased importance when protocols must be strictly followed to maintain the quality of the data.

2. **Description and practice of project protocols** - All participants need a detailed description of project protocols and procedures. These may include data collection, geolocation recording, identification, classification and analysis protocols. Additionally, training needs to include practice with all the above

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providing a level of familiarity with the practical aspects of the project and any technical/scientific equipment.

3. **Introduction to the project platform** - The platform refers to the communication, dissemination and data management mechanisms of the project. This may be a digital platform, but could also relate to practical resources, such as a community notice boards. Training should include an introduction and practice with the platform including ways to access and operate it.

Audience Specific Considerations

While the above needs were found relevant to all audiences, their context is slightly different for project facilitators and designers. Facilitators and designers are in turn, responsible for the facilitation and design of the project resources and need to be trained to do so.

Facilitators must be confident in communicating the practical aspects of the project to their particular audience, e.g. school pupils or community members. They must be familiar enough with the practical elements to respond to participant questions and they need to be comfortable with the pedagogical approach that the project is taking.

Project designers must ensure that the decisions taken in relation to the practical aspects of the project are the most appropriate for the project as a whole.

3.3. Engagement Needs

The engagement needs are concerned with training related to the personal needs of those involved in the project, as a means of providing a positive experience and retaining their motivation and participation.

1. **Recruitment approaches** - Recruitment is a key factor for the greater involvement of large audiences in citizen science projects and its advertisement. Participants need to know about the project existence and relevance in order to engage and participate in the project.

2. **Enjoyment** - Ensuring that the project is meaningful, engaging and enjoyable for everyone involved is a major consideration for participant retention. An enjoyable experience may mean different things to different people and audiences.

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3. **Communication** - Communication is key to the success of a project. It is vital therefore that all audiences understand the range of communication channels associated with a project (this may be between participants, between the participants and the project team, between the project team and the general community etc.) and how to make the best use of these.

4. **Reward and recognise progression** - Recognising the contribution of participants can be extremely meaningful for many of the audiences engaged. Such recognition, whether within the project (e.g. participant certification, most accurate spotter) or in association with external bodies (e.g. volunteer organisations, professional bodies) can maintain motivation and retention.

5. **Wider involvement** - Different audiences are interested in engaging in citizen science in diverse ways and should be provided with wider engagement opportunities. This could be within one project or between citizen science projects which participants are introduced to.

Audience Specific Considerations

Facilitators need to be able to communicate the recruitment, engagement and recognition opportunities to their participants and also be aware of these in their own particular capacity. Facilitators also have a role in communication between the participants and the project team and need to be able to pass on feedback from the participants' experiences in order to improve engagement in the projects.

Project designers need to consider recruitment, engagement and recognition in their project plan from the outset. Learning from current and past projects will enable designers to consider the most appropriate route for their project while integrating feedback routes will allow responsiveness within the project. Building and articulating connections to wider CS projects should be considered as both a route to recruitment and a mechanism of enabling wider community involvement.

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4. Training challenges

When designing training for different audiences, training designers may be faced with challenges related to the training needs, diverse audiences and complex logistics. This section describes the challenges in meeting the training needs described in the previous section. Since many of the challenges correspond to more than one need, they are discussed collectively, and not need-specific. We start with the more personal, audience related challenges, and move towards the project-related challenges.

1. **Diversity of audiences** - The training audience would typically be composed of people from diverse ages, backgrounds and motivations. This poses a challenge as to the training level and its adaptation to the attendees. Even a seemingly homogenous audience may possess a range of prior knowledge, skills and interests.

2. **Cultural gaps between stakeholders** - Citizen science projects typically bring together people from distinct communities such as scientists, volunteering citizens and school students, who may not share norms and values. For example, the importance of rigorous practices may be undervalued by non-scientists, while scientists working with schools may have trouble adapting to the school's organizational processes.

3. **Diverse participation patterns** - Trainers and participants often join the project with varying levels of commitment, as other interests and obligations compete for their attention. It is, therefore, challenging to create an environment where all audiences feel their participation is meaningful.

4. **Acquiring complex skills in limited time** - Training often provides basic skills, while expertise comes with time and experience. Since training time is limited, it is not clear that it will be sufficient to master the necessary tasks of the project.

5. **Limited resources** - Both training and project engagement require the investment of time, money and other resources, by all stakeholders (designers, trainers and participants). This poses a challenge as to prioritizing the different project needs and requirements.

6. **Seasonality** - Some projects are affected by seasonality in data collection (such as tracking migrating birds) or in participant attendance (such as making

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observations at beach areas). This poses additional challenges on the operation of the project, participant recruitment and retention.

7. **Broad agendas** - Some citizen science projects try to connect with a broader environmental, social or political agenda. These can be related to environmental hazards, community activism or policy-makers acceptance of citizen science data. This may pose a challenge on the design of training and recruitment of participants and as such demands sensitive design and responsiveness.

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5. Training recommendations

5.1. Recommendations for participants

Citizen science participants play a major role in citizen science projects and are often the active players contributing, collecting, classifying and in some cases analysing data for the project. Since participants can come from a range of backgrounds, their skills, knowledge and experiences are diverse. While one participant may be highly educated with vast scientific experience, a second participant may have much more practical experience such as a farmer or gardener. As such, many of the needs and challenges described above (chapter III), stem from the diversity of participants. As the accuracy in data collection and other tasks participants engage in, is very important for ensuring data quality and validity, training is an important step to bring everyone to the necessary level. This section outlines the training recommendations to support diverse audiences of participants in citizen science projects, addressing the needs and challenges identified above.

Addressing core needs

The first step in attracting participants in citizen science is to outline its unique nature, importance and contribution to science and/or society. Understanding what citizen science is, how it has developed over the years and been facilitated over the past decade with new technologies, can provide motivation for participants to take part in such projects. This should be supported by the training process which should provide information about what citizen science is, the scientific background of the project, its context and the relevance to society and participants' lives. With the particular relevance of the citizen science project explicitly communicated to participants, participants can attain a sense of understanding and further commitment to the topic and make an informed decision about their participation. They can better understand the importance of the project and its potential benefits and contributions. Our practical recommendations are hence:

1. **Provide a clear definition and history of citizen science** - Participants may come with no previous experience or knowledge of what citizen science is, its history and the opportunities it provides to science, individuals and communities. These should be explained through the training.

2. **Deliver project goals and scientific background** - Discuss the overarching goals of the project with participants and how the citizen science project assists in meeting these goals. Also, provide background to the scientific topic of the project

explaining what is known and unknown in this sphere and thus the importance of the project. This should all be delivered in very simple terms, understood by people with no scientific background and adaptable to the age of the participants.

3. **Relate the project to the training audience** - The particular relevance of the citizen science project should be communicated to participants during the training. This would enable them to connect to the project on a more personal level, understanding the local and global context of the project and relating it to participants' lives needs and interests.

By providing the core information about citizen science in general and details about the specific project the training is geared towards, participants can develop an understanding of the wider implications of citizen science, addressing questions about the global and local nature of the project that they are involved with. Adaptations may need to be made for different audiences, countries, regions and schools, taking into consideration variations in knowledge, scientific background, language and terminology, as well as cultural divergences in how different issues are perceived.

Addressing operational needs

In order to be able to participate in citizen science projects and contribute to their processes, participants need to have an understanding of the projects' procedures and practical elements. Information about project design should be expressed to participants, including the rationale for its design and how this design contributes to the scientific goals of the project (for example - seasons of data collections which correspond to species occurrences). Training should help participants become familiar with the process of participation, by providing hands-on training on data collection protocol, and/or any technical information the project utilizes (sensors/ platforms/ protocols). Our practical recommendations are hence:

4. **Explain project design** - The overall nature of the project design should carefully be communicated in response to the training audience. Since project protocols are often strict and changing them, even slightly, may affect and skew the data, the reasoning behind the design of project protocols and how these assists the scientific question at hand should be articulated to the participating audiences. For example - one should not try to collect information about a specific bird in winter since that bird species is not present in this season.

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5. **Describe and practice project protocols** - The description should include explanations of the protocol procedures and timings, in addition to the use of technical equipment if applicable. The mechanisms of use, parameters and limitations of the technology should all be defined as appropriate to each training audience. Importantly, training needs to include practice with all the above in addition to the explanations of use. The nature of how the protocols will be communicated with the different training audiences should be explained as they might have different needs or preferences in this regard.

6. **Introduce the project platform and practice its use** - The training should include an introduction and practice with project platform (communication, dissemination and data management mechanisms of the project). The nature of the platform, the manner of accessing this platform and its limitations should be clearly understood by the training audience. This may be a digital platform, but could also relate to practical resources, such as a community notice board.

As indicated, the level of knowledge and background of each participant is different at the beginning of the training program. Some cultural differences may also pertain a gap in ways participants engage and the level of their knowledge. For example, people may be more or less strict in the ways they follow protocols, people may be more aware of local issues in their specific region than others. Furthermore, participants will have different levels of independence within the project, for example, school pupils will have a teacher/facilitator present, and young children may be working with parents or older siblings. As such, the training needs to be flexible and correspond to the diverse needs and experiences of participants (Golumbic 2019). It is also important to point out that participants become more experienced over time and that practice transforms into better data quality. Therefore, participants should be given the time and guidance they need to achieve such expertise.

Addressing engagement needs

The contribution of citizens to the project may vary. While some citizens collect data directly, some may contribute to the project with different volunteering activities, such as verifying observations, helping new participants, writing up findings and sharing experiences and results. It is important to provide opportunities for highly motivated and/or skilled participants to engage in additional, perhaps more complicated tasks, for example in analysing data or developing new questions, in order to further their interests and participation. Ideally, citizens can contribute scientifically to different

stages of the citizen science project according to their interests, knowledge and skills levels.

To encourage project participation over time, some effort should be made into raising awareness about additional engagement and communication opportunities such as; rewards and acknowledgements for achievements, access to information about project progress and development and channels or events for socializing. Some popular formats to interact and communicate within the project community include the dissemination of project results and outcomes through various channels (for example social media, discussion groups, forums and blogs) and acknowledging participant contribution (for example receiving badges for achievements or highlighting contributions within the community). Additionally, information about the project life cycle, (when does it end, what products or scientific outcomes are expected and what happens to the data afterwards) should be transparent and accessible to participants. Our practical recommendations for engagement of participants are hence:

7. **Ensure a meaningful and enjoyable experience** - Participants should be encouraged to provide feedback on the project, ask for the information they are interested in, provide input and ideas from their perspective to ensure that their participation is recognised and important.

8. **Inform about communication methods** - Communication in citizen science projects includes the communication between participants and between the participants and the project team. Participants should be made aware of the channels that are available to ensure they can interact with the community if they wish to do so. Such communication features may include discussion groups, forums, social media and blogs which describe project results and outcomes.

9. **Reward and recognise contributions** - Opportunities to receive recognition and acknowledgement for their contribution to the project should be explained. Acknowledgment of participants' contributions may include providing certifications for participant contribution, assigning a volunteer of the week etc.

10. **Describe opportunities for wider involvement** - Opportunities for participants to become more involved in the project and contribute in additional ways such as volunteer coordinator, communicator etc, should be signposted during the training. In addition, participants may want to be introduced to other Citizen Science resources such as similar projects and information about setting up new citizen science projects.

5.2. Recommendations for facilitators

Citizen science facilitators play a number of important roles in Citizen Science projects, for example, they represent the 'face' of the project to the participants and play an intermediary role between the participants and the project design team. As such, they need to have knowledge and skills in a wide range of areas, including the scientific background, practical data collection and analysis, teaching and learning approaches and communication skills.

To achieve the project goals, facilitators must have a sound understanding of the nature of the Citizen Science project, the expected outcomes and the range of roles for participants in the project. It is also useful for them to have an understanding of citizen science projects more widely and be aware of the different participation models available.

It is worth noting that facilitators may be involved in the project initiation and project design, or they can be engaged once the project reaches its implementation stage. In addition, the facilitators may bring in their own expertise from different fields, some might be experienced teachers and educators while others might be more familiar with the science relevant to the citizen science project. The training needs of the facilitators will, therefore, be different in these cases and it is harder to provide generic recommendations and separate them into our three categories of needs. However, we suggest the following:

1. **Value expertise** - Educators as facilitators can bring in valuable knowledge, for example, about learning, best practice in facilitation, curriculum links and administrative processes in formal and informal education settings. So it seems reasonable to consider facilitator training not just as instruction and instead also allow time and space for them to contribute their expertise. Implementing improvements based on this might be easier during earlier project stages. When involved during the project design stage, facilitators may be able to evaluate different pedagogical approaches in relation to the scientific topic, the project goals and the target audience. When engaged after the design stage, they may have valuable input on how to tailor the project details to allow successful delivery of the project goals under specific conditions, e.g. develop or adapt lesson plans around a citizen science project for a school group and their curricular needs and financial, staff and time resources.

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2. **Familiarising with participant needs** - In achieving successful data collection or analysis sessions, the facilitators should be able to address the needs of different participants, both in groups and individually. Therefore, they need to be familiar with the core, operational and engagement needs of participants and how to address them and/or be aware of the routes and networks of support available for them. Facilitators ought to be informed about communication and engagement strategies and have opportunities to test and practice approaches in order to confidently put those into practice. Training should acknowledge the different experience and confidence levels that facilitators bring, and work to build confidence and agency in this audience throughout the project. The routes to evaluate the project experiences should also be clearly defined for the facilitators.

3. **Experience the project from a participant perspective but through a designers' lens** - Facilitators often are the mediators between participants and project designers or researchers. Training needs to ensure that the facilitators are familiar with the project protocols and modes of operations. We recommend having them take part as participants if the project allows. This will enable them to experience what it means to participate in the project and prepare them to help others through the process. To support facilitators' understanding of the protocols and modes of operation, it may be helpful to elaborate on the reasoning behind protocols and processes from the project designer perspective. This may include for example explaining why aspects of the protocol need to be followed rigorously and which consequences it may have if that is not the case or explaining potential limitations of the platform. Acknowledging the range of backgrounds that facilitators may have, it is important to use clear and simple language in all communication, avoiding overly specific scientific, technological and educational terminology. Additionally, ensuring straightforward translation into other languages should the project have an international component is recommended for the facilitators training resources.

4. **Reward and recognise contributions** - Opportunities to receive recognition and acknowledgement for their contribution to the project should be explained. Acknowledgment of facilitators' contributions could be similar to that of the participants but may also include providing certification that is recognised as professional development.

5. **Describe opportunities for wider involvement** - Opportunities for facilitators to become more involved in the project and contribute in additional ways such as coordinator, communicator etc, should be explained during the training. In

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addition, facilitators may want to be introduced to other Citizen Science resources such as similar projects and information about setting up new CS projects, research evidence about learning or scientific outcomes of citizen science participation. It may also be worth to consider informing them about how to become part of the wider citizen science community, e.g. informal citizen science meetups, Citizen Science Associations (ECSA, CSA) or initiatives like the Citizen Science COST Action (CA15212) or EU-Citizen.Science.

In conclusion, training for facilitators should be developed while taking into account the different backgrounds, needs and goals of the training audience in order to give them the confidence to successfully interact with the project and the participants to achieve their individual and project goals.

5.3. Recommendations for designers

Citizen science project designers need to address a wide range of issues when engaged in project initiation, design, and implementation. These include theoretical as well as practical knowledge on diverse issues such as citizen science, project management, team management and more. To tailor the project design to its specific goals and audiences, the project designer should have a common understanding about what citizen science is, the range of project types, and what outcomes can be expected from different citizen science approaches. Before the project design begins, designers need to map out the project objectives, identify potential partners and stakeholders and their needs, and establish funding and other resources that can help. To put up a realistic and engaging project plan, designers should address the needs of different facilitators and participants, define their required skills, and develop training protocols. An evaluation plan should be prepared, for making sure project goals are accomplished, in addition to the development of communication and community engagement strategies. In some cases, planning also includes the design of learning environments or technological platforms. The following section addresses the diverse tasks and considerations project designers should consider, taking into account the specific background knowledge, needs and goals of the training audience.

Addressing core needs

1. **Provide definitions and some background on citizen science** - To establish an understanding of what citizen science is and what it is not, using definitions

(e.g. Oxford English Dictionary) and the 10 Principles of Citizen Science (ECSA, 2015) may be helpful. A brief introduction to the history of citizen science will prevent the misconception that citizen science is a recent, new development. Showcasing 19th century naturalists and their work might be a good example to reflect on professional science as we know it today. Introducing typologies of citizen science (e.g. Haklay 2014, Shirk et al. 2012) and example projects for each type will show the range of possible project types. This can encourage project designers to critically assess project ideas with regards to the level of participation the different types offer and the scientific, educational or engagement goals they aim to achieve. Including evidence about what outcomes citizen science projects can accomplish may highlight the contribution citizen science has made to science and the educational outcomes for facilitators and participants. The presented evidence should take the training audience into account and specifically cater to their interests or concerns. This evidence can also be useful in conversations with management, other stakeholders and potential funders. There are several examples of guides or online and blended learning courses on citizen science that may be a valuable resource for project designer training, for example: “Citizen Science and Scientific Crowdsourcing: an Introduction” by Extreme Citizen Science (ExCiteS) research group at UCL or the “Guide to citizen science: developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK” by Natural History Museum and NERC Centre for Ecology & Hydrology for UK-EOF.

2. **Support decisions on project goals and scientific background** - The citizen science project should have clearly defined scientific goals and project aims. This will be helpful in further project planning as well as with communication with potential funders, media, facilitators and participants. Obviously, the science aspect requires knowledge that experts need to bring in whether they are the programme designer themselves, co-creating it with others or consulting on the project. Scientific knowledge and experience are necessary to develop a scientifically sound protocol for data collection ensuring that the data quality is robust and the data will actually be able to answer the research question. The scientific background itself cannot be covered within training for citizen science project designers. However, training programmes can support project designers in assessing whether citizen science is the best approach to investigate the scientific issue. Aside from considering public engagement and education goals and financial considerations, “citizen science lends itself better to certain types of data gathering and analysis than to others” (Tweddle et al. 2012). In addition to data

quantity and quality considerations, it is recommended to also consider whether a citizen science approach can actually meet the requirements of the data collection process for a specific scientific issue, e.g. data volume and the temporal and geographical scope. Based on the project ideas the training participants may have, these issues can be critically assessed during the training process and alternatives discussed. In addition, educational and engagement objectives should be discussed and defined. When defining goals, it seems reasonable to also cover formative and summative evaluation strategies to monitor whether the objectives have been achieved (e.g. DEVISE, Phillips et al. 2018).

3. **Relating to the audience** - Potential new citizen science project developers can come from a range of backgrounds, e.g. scientists, educators, outreach or public engagement professionals, NGOs, community-based organisations or concerned communities or individuals. Training for project designers aims to support people who wish to design and implement a citizen science project. Knowing as much as possible about the training audience in advance of the training will help to tailor the training based on their needs and experiences.
   For the project designers, it is important to decide which audience they want to take part in their programme, how to make the project relevant and accessible to their target audience and how to recruit participants accordingly. The training should discuss the benefits and challenges of working with particular audiences (e.g. school groups, community organisations, families, pensioners, etc.) and recruitment strategies.

Addressing operational needs

4. **Develop the project design** - Citizen Science projects vary in their design; some are seasonal, for example, some may require repeat participation, some might be restricted to a specific region, others allow for more flexible participation patterns and participant location. Additionally, projects can allow different degrees of participation, for example contributing data, getting involved in data analysis or actively co-creating a project (Shirk et al, 2012). Training should articulate the different approaches in order to help project designers choose the right one for their project idea. Training should also focus on practical aspects to help define the project life cycle:

   - When does the project start and end? This might be due to scientific, participation or funding reasons.
   - What resources (finances, time, staff, technology, etc.) are required/available?

- Who would be expected to take part and what would be required from participants? What could potentially motivate participants to take part?
- Who could facilitate participation?
- What products or scientific outcomes are expected?
- What happens to the data afterwards?

Funding is essential to projects and therefore is likely to have an impact on the project design. The available funding opportunities vary between countries, regions, topics and audiences and even types of projects. So, the more is known about the training audience, their project ideas and areas of interest, the better the advice on funding opportunities can be tailored to the audience. However, some general options include crowdfunding, governmental funding, sponsorship and the European Commission programmes (e.g. Horizon 2020, Horizon Europe, Erasmus+).

5. **Develop and implement project protocols** - The data quality as well as the required data volume and the temporal and geographical scope and rigour when it comes to data analysis are crucial to ensure that the citizen science project can deliver the intended scientific outcomes. Developing scientifically sound protocols is an essential step in the design process of new citizen science projects. The protocols need to be designed so that participants can easily follow them in order to guarantee the necessary data quality and scientific rigour. The process of developing such protocols should be addressed during the training of designers, articulating the needs for protocols to explain procedures and timings, the use of technical equipment and mechanisms of use, parameters and limitations of the technology (modifying protocols after the project launched may affect and skew the data). At this point, it can be helpful to research whether similar projects exist (for example in databases such as scistarter or Bürger schaffen Wissen), check whether protocols can be adapted, learn from other's experiences to identify and avoid potential pitfalls.

6. **Showcase project platforms and discuss affordances and constraints -** The decision for a project platform is most likely a project-specific one, yet we recommend showcasing existing platforms that could be used for new projects, e.g Zooniverse, iNaturalist, nQuire or Spotteron during the training and discuss them in terms of usability, suitability for project tasks, communication options, costs, access to data and data management. Training should include an introduction to, and practice with the proposed project platform (communication, dissemination and data management mechanisms of the project). The nature of

the platform, the manner of accessing this platform and its limitations should be clearly understood by the training audience. It seems like most projects use some kind of digital platform or app, yet analogue settings should be considered (e.g. recording forms, community notice boards) as well as the contingencies that can be used in adverse circumstances (e.g. lack of network coverage)

Addressing engagement needs

Aiming to encourage project participation over time, the training should provide insights into how to address engagement and communication needs, such as rewarding and acknowledging achievements, enjoyment, creating passion and socializing. This can be done, for example, by clear dissemination of project results and outcomes, creating discussion groups, forums and blogs and acknowledging participant contribution. Additionally, the project life cycle, (when does it end, what products or scientific outcomes are expected and what happens to the data afterwards) needs to be communicated in a transparent way.

7. **Ensure a meaningful and enjoyable experience** - While this may mean different things to different people and we acknowledge that some scientific tasks can be quite tedious, it is important to maintain a sense of positive engagement for the retention of participants. This may be best accomplished by “knowing your audience”, understanding their needs and motivation for participating and accommodating project engagement and training activities to these needs. A good match between the interests of the target audience for recruitment and project tasks is important.

8. **Develop communication strategies and channels** - Communication in citizen science projects includes the communication between participants or between the participants and the project team. For both, strategies should be developed and the channels and format embedded from the start. Such communication features may include discussion groups, forums, social media, webinars and blogs which describe project results and outcomes. The benefits and options to establish community engagement professionals or moderators should be discussed during the training.

9. **Reward and recognise contributions** - To increase the motivation of participants to engage actively with the project over time, options to incorporate recognition and acknowledgement of participants’ contribution to the project should be explored during the training. Acknowledgment of participants’

contributions could, for example, include providing feedback on project contributions, certificates to use for further or higher education applications, contributions to youth pass or other volunteering awards or badges (e.g. Girlguiding, Scouts), honouring a volunteer of the week, badges for contributions or acknowledgement in or co-authorship of scientific papers. It is also important to provide a mechanism for recognising facilitators and their participant groups independently from each other, to ensure that, for example, when a teacher moves school or a class progresses to a new stage, the project involvement and recognition can be accessed by both parties separately.

10. **Explore opportunities for wider involvement** - Project designers should think about opportunities for more highly motivated participants to become more involved in the project and contribute in additional ways such as becoming a volunteer coordinator, communicator etc. In addition, designers may think about how they can introduce participants to other citizen science resources such as similar projects and information about setting up new citizen science projects. They should consider communication and engagement beyond the project. Can they, for example, establish connections to other related citizen science projects, campaigns or interest groups to use synergies in communication, funding or recruitment efforts?

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3. Resources

To support training providers, we have started collecting useful resources in an open access google spreadsheet and invite the community to add to the resources list by entering information about available resources via a google form. The following includes resources that can assist the process of designing training for citizen science for all audiences. Each resource will be briefly described followed by a link to access the full resource.

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4. Summary

In this report, we aimed to systematise and elaborate on the ideas discussed during the COST Action WG2 workshop “Systematic review on training requirements and recommendations for Citizen Science” that took place in Riga on 12-13th November 2018. Building on the input from the workshop participants’ broad range of different perspectives and expertise in citizen science and education, we compiled a list of training needs for project participants, project facilitators and project designers in citizen science and categorised them into core, operational and engagement needs. Based on our experience we discussed challenges that may need to be considered when designing training in citizen science. We then addressed the needs by formulating recommendations and pointing out available resources that have been proven to be useful in our own citizen science research and practice. While we acknowledge that these training needs and training recommendations may not be complete, we believe that our approach from needs to recommendations can act as a helpful working model when designing training and the list of resources provides a starting point to delve deeper into the topic and good training examples to build on. We invite the community to provide further insights into training needs and recommendations and to contribute further resources to the list.

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