CitiMeasure

Using citizen measurements to create smart, sustainable, and inclusive cities

CitiMeasure guidelines on competencies for digital inclusion

Publication Year: 2022

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Acronyms

EC	European Commission
CS	Citizen Science
CSA	Citizen Science Association
DG	Directorate General
DOI	Digital Object Identifier System
EU	European Union
IDE	Integrity, Diversity and Equity
GDPR	General Data Protection Regulation
ICTs	Information Communication Technologies
JRC	Joint Research Centre
NGO	Non-Governmental Organization
NILU	Norwegian Institute for Air Research
Scivil	Citizen Science Vlaanderen
SDU	South Denmark University
UCD	University College Dublin
WG	Working Group

1. Executive summary

The CitiMeasure Digital Inclusion guidelines aim to advance the understanding of the issue of 'competencies' for digital inclusion in citizen science. One of the main contributions of these guidelines is unpacking the issue of competencies by identifying types of skills, knowledge, and attitude that may be required for inclusion of citizens in citizen science initiatives and those required by project initiators to establish and run such initiatives. The current guidelines also provide a set of recommendations on how to systematically think about and enhance competencies of these actors.

These guidelines are result of a co-creation process led by Eurocities in close collaboration with the CitiMeasure Digital Inclusion working group members. The co-creation process included a joint effort for identifying and sharing relevant resources and experiences, as well as joint analysis and sense making of the identified resources. As such, it reflects the collective understanding and experiences of 24 CitiMeasure working group members from 7 European cities and 9 organizations with interest and expertise in the topic.

2. Introduction

2.1 PURPOSE OF THE GUIDELINES

The CitiMeasure Digital Inclusion guidelines aim to advance the understanding of the issue of 'competencies' for digital inclusion. This is done by unpacking competencies required by citizens to participate in citizen science initiatives, as well as those of project initiators (including scientists, municipal employees, decision makers, and policy makers) to engage citizens in such initiatives. In the current guidelines competencies are understood as a construct of skills, knowledge, and attitude. Understanding competencies such as skills and knowledge required by citizens to participate in a citizen science initiative and their attitude towards participation e.g., in terms of their ability for, or added value of, getting involved, is a prerequisite for enhancing those competencies. Similarly, understanding competencies of project initiators such as required skills, knowledge for setting up and engaging citizen science initiatives, and attitude towards uptake of citizen-contributed data and information is crucial for realizing the full potential of these initiatives.

2.2 WHO ARE THESE GUIDELINE FOR?

The CitiMeasure Digital Inclusion guidelines are primarily developed to guide those who are interested in identifying, understanding, and enhancing capacities and competencies required for digital inclusion of different actors in citizen science projects. This includes cities, organizations, researchers, and practitioners who are involved in initiating a citizen science project, or those who aim to study or improve current actor inclusion practices in existing citizen science initiatives.

We also hope that these guidelines are informative for those who are interested in the broader topic of competencies for public participation and stakeholder engagement.

2.3 WHAT CAN YOU EXPECT TO FIND IN THE GUIDELINES?

Section 3 of the guidelines provides background information about the CitiMeasure project and these guidelines. This includes a description of the project and the CitiMeasure Digital Inclusion working group that has developed the guidelines, as well as a description of the methodology followed for developing the guidelines.

The main content of the guidelines is summarized in Section 4.3. This section starts with challenges and needs related to digital inclusion and the link to the issue of competencies. We then use the concept of Changemaking as a point of departure to explore purpose and applications of citizen science. One of the main contributions of the guidelines is unpacking the issue of competencies and identifying categories of skills, knowledge, and attitude for digital inclusion in citizen science, which is summarized in the sub-sections of section 4.3.3. The presented (sub-)categories are informed by a wealth of theoretical and empirical resources and the collective experiments and expertise of the CitiMeasure working group members. Not every (sub-)category of skills, knowledge, and attitude presented in this section may come across as 'technology-focused' or 'digital'. This is because we believe digital inclusion cannot be studied and discussed in isolation, and there are a wide range of more generic skills, knowledge, and attitude categories that come into play when discussing a citizen science initiative. Section 4.3.4 also provides a set of recommendations on how to systematically think about and enhance competencies of actors involved in citizen science initiatives.

2.4 WHAT THIS GUIDELINE IS NOT?

There are many things that these guidelines are not, but we would like to emphasize a few:

- This is not a step-by-step guideline to identify and enhance competencies for digital inclusion.
- Although we've built on several resources and expertise of 24 individual members of this working group, this shouldn't be considered as a comprehensive inventory of all possible categories of skills, knowledge, and attitude for inclusion in citizen science.
- Several of the recommendations in Section 4.3.4 are linked to specific categories of skills, knowledge, and attitude, however, there is no one-to-one relation between the identified competence categories and the recommendations.
- Lastly, we also would like to emphasize that absence of certain skills, knowledge, or attitude identified in this guideline shouldn't be considered as a reason for exclusion or discouragement of interested stakeholders and individuals from participation.

2.5 WHO TO CONTACT FOR QUESTIONS OR FEEDBACK?

If you have any questions, or would like to give us feedback about these guidelines, please write an email to Mohammad.gharesifard@eurocities.eu

2.6 LIST OF CONTRIBUTORS

These guidelines are the result of an iterative co-creation process with inputs from members of the CitiMeasure Digital Inclusion Working group. The members of this working group are affiliated to 7 European cities and 9 (non-)governmental and research organizations (see Figure 5). In particular, 11 out of the 24 individual working group members have contributed to these guidelines by providing resources, and/or critically reviewing those resources. The detailed list of contributors and their affiliations are provided in Table 2. In addition to contributors from the working group, Table 2 also includes the name and affiliations of two Eurocities team members who have been involved in developing the guidelines, as well as one external expert (Margaret Gold) who contributed to the development of these guidelines by reviewing 10 resources.

WG member	Affiliation
Alena Bartonova	NILU
Anna Berti Suman	JRC
Emily Daemen	The Green Land
Gino Dehullu	Roeselare
Irene Vivas Lalinde*	Eurocities
Kasper Van Hout	Murcia
Margaret Gold**	Leiden University
Metodiyka Tarlyovska	Sofia
Miriam Calvera Isabal	Universidad Pompeu Fabra
Mohammad Gharesifard*	Eurocities
Paolo Palomba	Milan
Peter van Waart	Rotterdam University of Applied Sciences
Tomasz Jaskiewicz	Rotterdam University of Applied Sciences
Youetta de Jager	ICTU

**Eurocities team members*

***External Expert*

Table 1 Contributors to the guidelines by providing resources, and/or critically reviewing those resources

3. Background

3.1 ABOUT CITIMEASURE

Citizen measurement (or citizen science) initiatives contribute to a sustainable transition of European cities towards resilient, healthy and inclusive living environments. By using an array of tools and instruments, citizens can play a role in the measurement and monitoring indicators on air quality, temperature, soil moisture, biodiversity, or risk management, among other environmental areas. Citizen measurement initiatives also can foster communications and interactions among stakeholders and contribute to the democratisation of science and policy. The CitiMeasure project (2021-2023) aims to bring together the experiences and expertise of European cities, organisations and networks in implementing citizen science initiatives (in the form of guidelines, toolbox, web-platform, Apps, etc.). The project builds upon the lessons learned from the Dutch City Deal Working Groups, a network of stakeholders working on the broader area of smart cities, including citizen measurement initiatives. The City Deal partners have been working closely with the Dutch Ministry of Interior and Kingdom Relations for over a year.
CitiMeasure builds upon these experiences and will use those to develop and pilot three 'instruments', namely:

1. An instrument that allows the outputs of different city measurement initiatives to be compared.
2. An instrument that safeguards the digital inclusivity of city measurement initiatives (maximising the opportunities for participation of interested individuals and communities).
3. An instrument that connects information to behaviour and policy change.

A 4th (Strategy and Oversight) working group focuses on providing strategic direction and ensuring cohesion of activities across the three Instrument Sub-Groups and the project in general. CitiMeasure will also raise awareness of the importance of citizen measurement initiatives and capitalise on the

results and tools of similar citizen science projects by creating an online European Knowledge Centre with a repository of good practices.

3.2 ABOUT THE CITIMEASURE DIGITAL INCLUSION WORKING GROUP

The Digital Inclusion working group is one of the three CitiMeasure working groups developing an instrument to create sustainable, inclusive, and smart cities. The group was initially formed through a call for expressions of interest that was shared through the Eurocities and City Deal networks, as well as personal networks of the CitiMeasure team. In September 2021 and following an inception meeting, the group started to co-design a shared vision and a number of objectives that help advance the understanding of the issue of competences for digital inclusion. Since September 2021, and following a co-creation approach, Eurocities has supported the development of the current set of guidelines to unpack competencies required by citizens to participate in citizen science initiatives. This was done by organizing and facilitating monthly online meetings, as well as communications with the working group members to share knowledge, experience, and resources for creating those guidelines. Currently, the working group has 25 members from 7 cities, and 9 governmental, research and other organisations.

Cities	(Non-) governmental and research organizations
• Barcelona • Debrecen • Milan • Murcia • Roeselare • Rumia • Sofia	• ICTU • Joint Research Centre (JRC) • Leiden University • Norwegian Institute for Air Research (NILU) • Rotterdam University of Applied Sciences • Scivil • The Green Land • Universidad Pompeu Fabra • University College Dublin (UCD)

Figure 1 Cities and (non-)governmental organizations that are member of the CitiMeasure Digital Inclusion working group

Here are the co-designed vision and objectives of the working group:

Vision: "The CitiMeasure Digital Inclusion WG works towards advancing the understanding of the issue of 'competencies' for digital inclusion. This includes both unpacking competencies required by citizens to participate in citizen science initiatives, as well as those of policy makers, decision makers and municipal employees to engage citizens in such initiatives."

Objectives:

1. Share ideas, case studies, best practices of digital inclusion in citizen science initiative, with a close attention to issue of competencies.

2. Jointly analyse and document competencies (knowledge, skills, attitude) required by citizens to participate in citizen science initiatives, as well as those of policy makers, decision makers and municipal employees to engage citizens in such initiatives.

3. Map the identified competencies against specific purposes/applications for citizens, policy makers, decision makers and municipal employees.

4. By April 2022, develop a guideline that helps cities and citizen science initiatives to understand, identify and enhance capacities and competencies required for digital inclusion of different actors.

5. Pilot the developed guideline in at least one real life example of citizen science initiatives between May and December 2022.

6. Consolidate the guidelines with lessons learned from the pilot phase and further analysis by March 2023.

Besides the Inception Meeting, seven co-creation sessions were organized to work towards development of the current guidelines. Throughout the co-creation sessions, the working group developed different elements paving the wave to create these guidelines. Development of the shared vision and objectives as described above framed the scope of the work. In November 2021, the working group adopted an implementation plan for the different actions needed to produce their desired outputs. From December 2021 until February 2022, the working group members collected and shared resources such as academic articles, project reports and deliverables, policy documents, and other useful sources of information, such as toolboxes and webinars. The resource collection was conducted in parallel with the resources analysis by members and Eurocities staff. Figure 6 described the key outputs of all the CitiMeasure co-creation sessions. For further elaboration on the co-creation process of the guidelines is presented in Section 3.3.

Inception meeting (Sept)

- Kick-off of working groups
- First version of co-cretated vision and objectives

First co-creation session (Oct)

- Validated vision and objectives

Second co-creation session (Nov)

- Co-created implementation plan

Third co-creation session (Dec)

- Co-created approach and structure for resource collection and analysis
- Roles and responsibilities

Fourth co-creation session (Jan)

- Progress with resources collection and analysis
- Co-created guidelines structure

Fifth co-creation session (Feb)

- Progress with resource collection and analysis
- Shared understanding of reviewed content by discussing reviewed resources

Sixth co-creation session (March)

- Refined content (working session on the content of the guideliens)

Seventh co-creation session (March)

- Refined content (working session on the content of the guidelines)

Figure 2: Key outputs of all the CitiMeasure co-creation sessions

3.3 DEVELOPMENT OF THE GUIDELINES

The CitiMeasure Digital Inclusion guidelines were developed using the following methodological steps and approach:

Definition of the scope

With the support of the Eurocities team, the working group members defined a shared vision and six objectives (see Section 4.2.1). Objective 4 specifies that the members found 'guidelines' as the most appropriate format for the outputs of this working group.

Resource collection and initial scanning

Based on the vision, the working group members and the Eurocities team collected and shared resources on competences including skills, knowledge and attitudes in the context of cities and citizen science initiatives. A shared online workspace (SharePoint) was created so that working group members can easily access and share resources. The working group members and the Eurocities team volunteered to perform an initial scan of the resources and made a suggestion for their inclusion of exclusion for an in-depth review. To standardize the resource collection/suggestion process, the following structure (in form of a table) was developed and proposed by Eurocities and validated with the working group members during the third co-creation session.

- Name of the file
- Year of the publication
- Language
- Title of the resource
- Type of resource
- Keywords
- Link
- The person who suggested the resource
- Relevance for the instrument
- Name of the reviewer
- Progress review
- Starting date and review deadline
- Notes
- Should everybody review this resource?
- Is this a difficult resource to review?
- Include or discard?

Analysis of individual resources

The working group members and the Eurocities team volunteered to analyse the collected resources. Similarly, a structure was designed by the Eurocities team (in form of a table) and validated by the working group members. This structure included the following information and allowed for a uniform analysis of the shared resources:

- Name of the file
- Type of the resource – Paper, report, audio, deliverable, website, etc.
- Name of the reviewer
- Competences – knowledge, skills, and attitudes described in the resource
- Stakeholders and roles - Does the resource refer to a specific stakeholder group such as citizens, authorities, researchers, etc? Does it refer to specific roles e.g., data generators, end-users of data, etc.?
- Viewpoint (if possible) – Indicate if the resource approaches the topic from a specific viewpoint, perspective, or with certain assumptions or methods.
- Specific purposes/applications - Map the identified competencies against specific purposes/applications for citizens, policy makers, decision makers and municipal employees.
- Main research questions and findings
- Relevance for the instrument
- Limitations.
- Notes

Due to the large number of resources and time limit, an external expert was hired to review 10 resources using the same structure.

Peer review and quality control

The Eurocities team checked the individual reviews in terms of completeness and quality, and when necessary either completed the analysis table with missing information from the resource or re-opened the resource for review by the members or the external expert.

Synthesis of the reviews

Synthesizing the insights from individual reviews, was done by adopting an indictive analysis approach. Without prior conceptions in mind, the assessment of individual reviews was done by coding the content and allowing for categories of insights to emerge from the reviews. Coded insights from one resource were checked and compared against coded insights from other resources to create categories of information. The main categories of coded content included competencies, specific purposes/applications, challenges and needs of citizen science initiatives, empirical insights/evidence, definitions, target group(s), and recommendations for enhancing competencies for digital inclusion. Constant comparison of the labelled content resulted in shaping the content that are summarized in Section 4.3.3 of these guidelines.

Drafting the guidelines:

The Eurocities team drafted an initial version of the guidelines and organized two working sessions with the working group members to work towards developing the first draft of the guidelines. The working group sessions took place in March and April 2022. In the first session, participants were divided into two groups, one working on skills, and the other group on knowledge component of the guidelines. Participants reviewed the content in terms of structure, formulations, and categories of findings. In the second session, all the participants reviewed together the wording and categories of the skills, and attitudes. The working version of the guidelines was shared online with working group members to provide room for reflection outside of the working sessions, and to allow members who could not attend the working sessions to provide their contributions.

4. Competencies for digital inclusion in citizen science

These guidelines aim to advance the understanding of the issue of competencies for digital inclusion. The following sub-sections focus on describing purposes, application, challenges, and needs related to digital inclusion in the field of citizen science. We will then discuss categories of skills, knowledge, and attitude required for participation of citizens or project initiators and provide a number of recommendations on how to overcome barriers for inclusion.

4.1 CHALLENGES AND NEEDS

Citizen science projects increasingly use digital technologies to engage with a wide range of stakeholders and audience. Digital inclusion in the field of citizen science is closely linked to having the right set of skills for inclusion, knowledge of certain topics or processes, and desirable attitude. Lack of balance or inequalities in such competencies sometimes among the main reasons for exclusion of some parts of the society (1). Widespread use of Information and Communication Technologies (ICTs) such as mobile phone applications and low-cost sensor devices in citizen science projects is considered as a powerful enabler of collaboration among many. ICTs make it easy to collect, store, share and discuss data and information in a citizen science project. At the same time, use of new technologies may (unintentionally) exclude parts of the society from participation in citizen science

projects, and foster 'digital divide' between those who can, or are willing, to use technology, and those who can't or don't want to (1, 7, 11).

Enhancement of skills, knowledge, and attitude of the general public for participation in citizen science initiatives, and competencies of project initiators to engage citizens in such processes is needed to increase the chance of inclusion for all. However, it is very difficult to measure change in skills, knowledge, and attitude when participating in citizen science initiatives (10). Without a good understanding of typologies of skills, knowledge and attitude required by citizens to participate in citizen science initiatives, or those of project initiators to engage citizens in such initiatives, it is not possible to systematically measure and consequently enhance those competencies.

4.2 PURPOSES AND APPLICATIONS OF CITIZEN SCIENCE

Changemaking is one of the cross-cutting principles and purposes of citizen science initiatives. Changemaking is defined as change in individuals, communities, cultures, and/or institutions, as well as changes in thinking, attitudes, behaviour, and values (22). Citizen science initiatives provide various opportunities for co-production of knowledge, learning, gaining skills, change of attitude and behaviour, and communication with a wide range of audiences (2, 4, 9). ICTs play a key role in such processes and allow fast and widespread interactions between all actors. On the one hand, participation in citizen science initiatives can equip citizens with required knowledge and skills to get involved in science or policy processes, and through that help change the relationship between citizens, scientists, and policy makers (15). On the other hand, policy and decision makers can tap into the collective power of the crowd to better understand and address global or local challenges. This is done through bridging the existing divide between citizens, scientists, and policy/decision makers, through close interactions and information exchange (15).

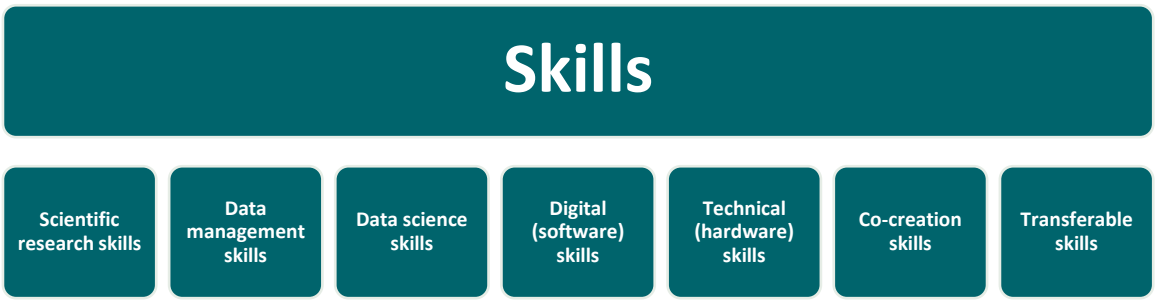
4.3 CATEGORIES OF COMPETENCIES FOR DIGITAL INCLUSION

In the current guidelines competencies are understood as a construct of skills, knowledge, and attitude. This part of the guidelines unpacks different types of skills, knowledge, and attitude that can facilitate participation of citizens in citizen science initiatives, as well as those of project initiators (including scientists, municipal employees, decision makers, and policy makers) to engage citizens in such initiatives. This sub-section of the guidelines also includes boxes with 13 examples that illustrate how different citizen science initiatives can foster participants' skills, knowledge, or attitudes. Where possible, the relevance of skills, knowledge and attitude is indicated for the following target groups:

- ***Citizen scientists***
- ***Project initiators/facilitators***: Those involved in setting up and/ or running the citizen science initiative (including scientists, municipal employees, decision makers, policy makers, and citizens in case they assume that role)
- ***Information professionals***: Those involved with management of data, including librarians and professional data management staff

4.3.1 Skills

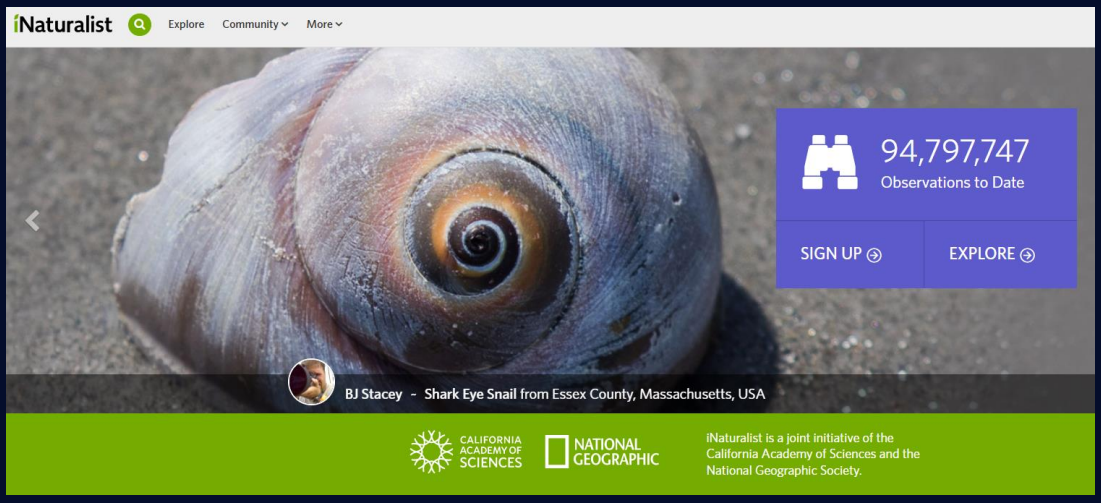
Seven main cluster of skills were identified as relevant for digital inclusion in citizen science. This includes (I) Scientific research skills, (II) Data management skills, (III) Data science skills, (IV) Digital (software) skills, (V) Technical (hardware) skills, (VI) Co-creation skills, and (VII) Transferable skills. Each skills category is relevant for one or more of the target groups that were defined in the beginning of this section. Furthermore, each cluster includes a number of sub-categories of skills, along with references to resources that mention those, and some examples from real-life citizen science projects (see Box 1 to Box 5).



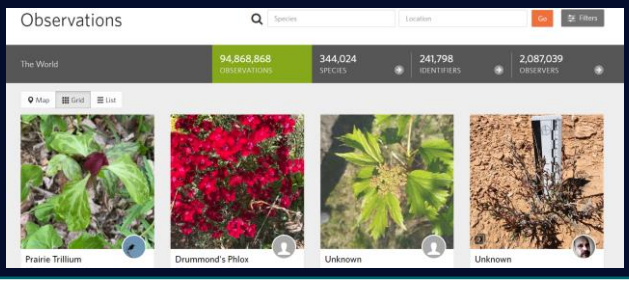
I. **Scientific research skills (2, 9, 26, 36):** ***Citizen scientists, project initiators/facilitators and information professionals***

- Research design and execution (2, 6, 25, 31, 37) - ***Citizen scientists & project initiators/facilitators***
    - Practical and methodological skills for planning and carrying out scientific research (26)
    - The capacity to involve citizens in the collection and analysis of research data (14)
    - Asking research questions (2)
    - Answering research questions (37)
    - Scientific reasoning and argumentation skills (2, 5, 6, 26,31, 37)
- Data collection (2, 37, 34) - ***Citizen scientists***
    - Observing and recording (9, 12, 13, 26, 31)

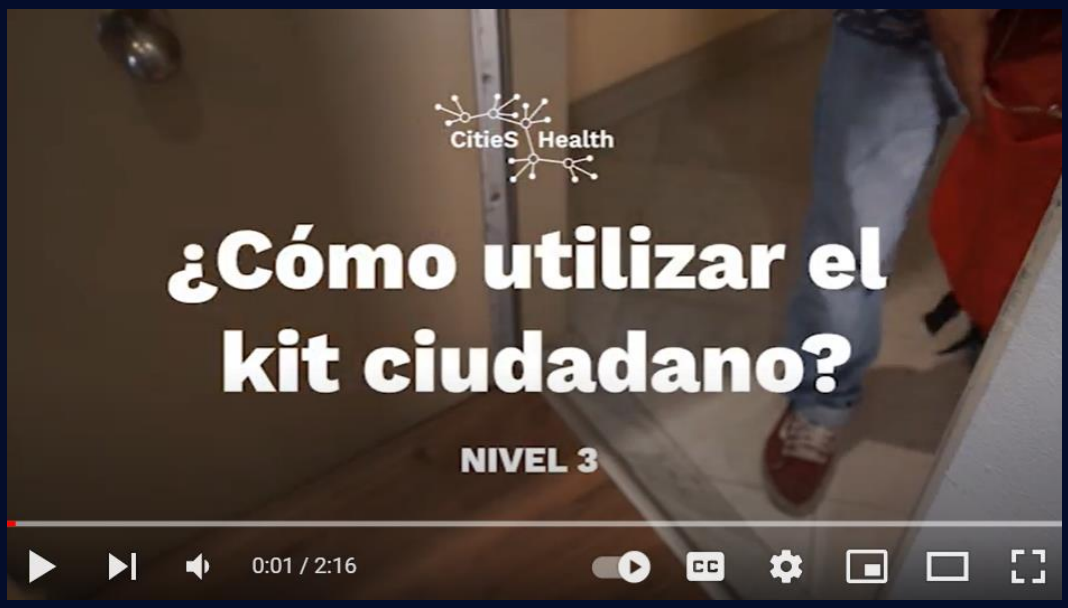
BOX 1: Observing and collecting data about biodiversity



More than 5M people have collected 94M data observations to date. Participants contribute to science by recording observations of different animal and plant species (see picture 2) and sharing them with a wider community of citizen scientists, researchers, and fellow naturalists for further discussion.



BOX 2: Data collection in CitieS-Health



This scientific enquiry was co-created with the citizens of Barcelona to explore how pollution (air, noise, etc.) in cities affect the mental health and stress levels of its inhabitants. CitieS-Health distributed a kit to collect data which was used by 300 participants. Based on the geolocation, the project has estimated how much contamination each participant is exposed to. The team used videos to explain the whole process (including data collection) to future participants.

www.citieshealthbcn.eu

    - Collecting data in a standardized manner
    - Submitting observations to the project database
- Data analysis (2, 34) - ***Citizen scientists & project initiators/facilitators***
    - Data interpretation (making sense of collected data and observation in relation to the context) (2, 9, 12, 13, 23, 31, 35, 37, 38)
    - Data quality control
    - Experimenting with the data
    - Synthesis
- Scientific communication and dissemination - ***Citizen scientists, project initiators/facilitators and information professionals***
    - Scientific communication skills, including publication-related skills and reporting (2, 13, 14, 37)
- Research integrity, ethics, and legal aspects (14) – ***Project leaders/facilitators***
- Integrating concepts of equity (needs-based approach) and equality (absence of discrimination) into the research process (CitiMeasure working group[1]) – ***project initiators/facilitators***
    - Recognizing social power relations and their implications on distributions of skills, knowledge, attitudes, and underlying resources, as well as on procedures (e.g.,

[1] Based on the experiences of the CitiMeasure working group members

participation in the citizen science initiative and outcome of decision-making processes),
    - Identifying sociodemographic characteristics associated with discrimination that might become relevant in the specific research context
    - Identifying solutions in discriminatory formal and informal access rules as defined by (semi-)public institutions, (local) economies, and communities.

II. Data management skills (13, 14, 17): Project initiators/facilitators and information professionals

- Handling and storing data
- Data annotation and documentation
- Taxonomy and ontology creation
- Data analysis/use/reuse
- Open data skills
- Respecting legal, and other constraints, e.g., handling sensitive data and complying with GDPR rules
- Knowledge about existing repositories and how to use them

III. Data science skills (14, 39): Project initiators/facilitators, and information professionals

- Collation of relevant scientific data
- Data verification and quality control
- Metadata creation and management
- Use of taxonomies and ontologies
- Data mapping
- Handling big data sets
- Data mining

IV. Digital (software) skills (2, 20, 23, 26, 31, 33, 34, 36, 38): Citizen scientists, project initiators/facilitators and information professionals

- Operational skills (actions required to operate a digital medium such as a computer or smart phone) (1, 10, 21)
- Information skills (browsing, searching, selecting, and evaluating information in digital media e.g., search engines) (1, 10, 11, 17, 18, 30, 21, 34).
- Communication and collaboration skills: mailing, contacting, interacting, creating, and managing online identities, drawing attention, and giving opinions through digital technologies (10, 17, 18, 21, 30).

BOX 3: The Co-Act project

The CoAct for Mental Health is a participatory research project co-designed and led by citizens. The project uses a chatbot as a tool to run the project and investigate the social support networks of adults (+18 people). The chatbot displays micro stories written by co-researchers with experiences on mental health in English, German, Spanish and Catalan.

https://coactproject.eu/

- Strategic skills: using the digital medium as a means to achieve particular professional and personal goals (1, 10, 17, 18, 21)
- Content creation skills: making contributions to the internet with a particular plan or design, developing, integrating, and re-elaborating digital content, copyright and licenses, programming (10, 17, 18, 21, 31).
- Scripting and coding skills (26)
- Developing and using models (37)

- Safety skills: protecting devices, personal data and privacy; protecting health and well-being (17).

BOX 4: The CSI-CO project

This EU-funded project mobilises citizen scientists from across Europe and beyond to investigate the different types of trackers in cookies and apps. The project developed the 'Your Right to Privacy Online' course and delivered it online and in-person where appropriate. Inclusive dissemination activities included: Parent-teacher roundtables and data-privacy stakeholder cafés.

https://csi-cop.eu/

V. Technical (hardware) skills (23,32, 33, 36, 38): Citizen scientists and project initiators/facilitators

- Setting up and maintenance of a device (20, 21)
- Use specific tools or technology provided by the project (34, 22)

VI. Co-creation skills (22, 38): Project initiators/facilitators

- Skills needed by project leaders and facilitators to co-create in a multi-stakeholder setting during the different stages of a citizen science project (e.g., scoping, planning, implementation, evaluation)

- Dialogue and facilitation skills (15,22), Strong dialogue and facilitation skills are required by project leaders to moderate discussions, reach consensus and support the co-existence of different views.

VII. Transferable skills: Citizen scientists, project initiators/facilitators and information professionals

- Problem framing and solving skills (6, 17, 25, 26, 28), formulating and solving problems, identifying needs and potential responses or resources to mitigate and/or adapt, creative use of technology, identify competence gaps, etc.
- Critical thinking (2, 6, 12, 23, 26, 28, 37), to assess information and arguments, identify assumptions, challenge the status quo, and reflect on how our background influences thinking and conclusions, recognizing different viewpoints.
- Analytical skills (23)
- Library and research information skills (13, 14)
- Leadership skills (14, 38)
- Interpersonal skills e.g., building trust (12, 14, 32)
- Stakeholder and community management skills (13, 31, 32)
- Teamwork and collaboration ability (Volunteers need to communicate with project team members in a timely manner, help each other and cooperate to complete tasks; Organization and coordination ability, Harmonious coexistence) (7, 14, 34).
- Generic communication skills (2, 13, 23, 26, 28, 31, 37)
- Generic project management skills (13)
- Creativity (28)
- The skills of how to perform in a certain environment e.g., first aid skills in the wild, using motor vehicles, and the ability to avoid dangerous species (34, 38).
- Skills to provide trainings (9)

BOX 5: Enhance knowledge and skills through trainings

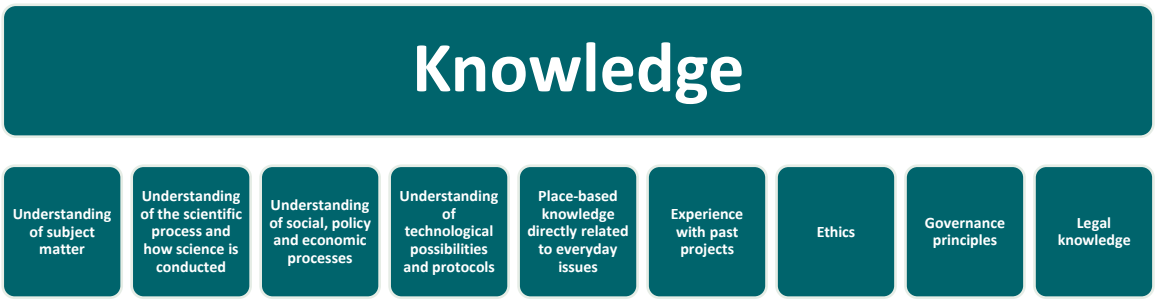
A study researching more than 48 biodiversity citizen science projects in Europe and Australia suggested that participating in training throughout the project was positively associated with participants' perceived gains in knowledge and skills. Other important elements were the information they received from the project, the amount of interaction they had with other project participants and with project staff and scientists, and the feedback and recognition they received from the project (2).

@EU Citizen.science MOOC

- Skills to receive training (Volunteers can be able to seriously participate in the project training, learn the rules and regulations of the project; understand project background and participate in training) (34)
- Geographic (reading a map, or finding a direction) (23)
- Physical fitness (Volunteers need to be physically fit and able to adapt to tough conditions; good health) (34).
- Evaluation skills (28)
- The ability to identify relevant social, political, and economic stakeholders in one's own community and region (28)
- STEM skills (23, 31)
- Literacy and language (Volunteers need to have basic knowledge such as reading, writing, (English) language) (11, 23, 27, 30, 31, 34, 38)
- System thinking (28), i.e., the ability to combine different disciplines, knowledge cultures and divergent views to initiate systemic change.
- Exploratory thinking (28): To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods

4.3.2 Knowledge

There are nine main cluster of knowledge that were identified as relevant for digital inclusion in citizen science. This includes, (I) Understanding of subject matter, (II) Understanding of the scientific process and how science is conducted, (III) Understanding of social, policy and economic processes, (IV) Understanding of technological possibilities and protocols, (V) Place-based knowledge directly related to everyday issues, (VI) Experience with past projects, (VII) Knowledge of ethics, (VIII) Understanding of governance principles, and (IX) Legal knowledge. Each knowledge category is relevant for one or more of the target groups that were defined in the beginning of this section. Descriptions and references are used to elaborate each knowledge category and clarify its source.



I. Understanding of subject matter (2, 5, 6, 9, 12, 23, 24, 28, 31, 32, 34, 35, 37): Citizen scientists and project initiators/facilitators

- e.g., wildlife knowledge, Biodiversity knowledge, environmental knowledge, geographic knowledge, biological knowledge, hydrological, sustainability and future scenarios

BOX 6: Learning outcomes of online citizen science

The impact on participants' learning in citizen science projects and the methods to measure such impacts are under researched. Studies on participation in online citizen science initiatives such as Zooniverse or iSpot have found that increased participation more likely results in enhanced learning gains and leads to learning outcomes such as topic-specific knowledge (31).

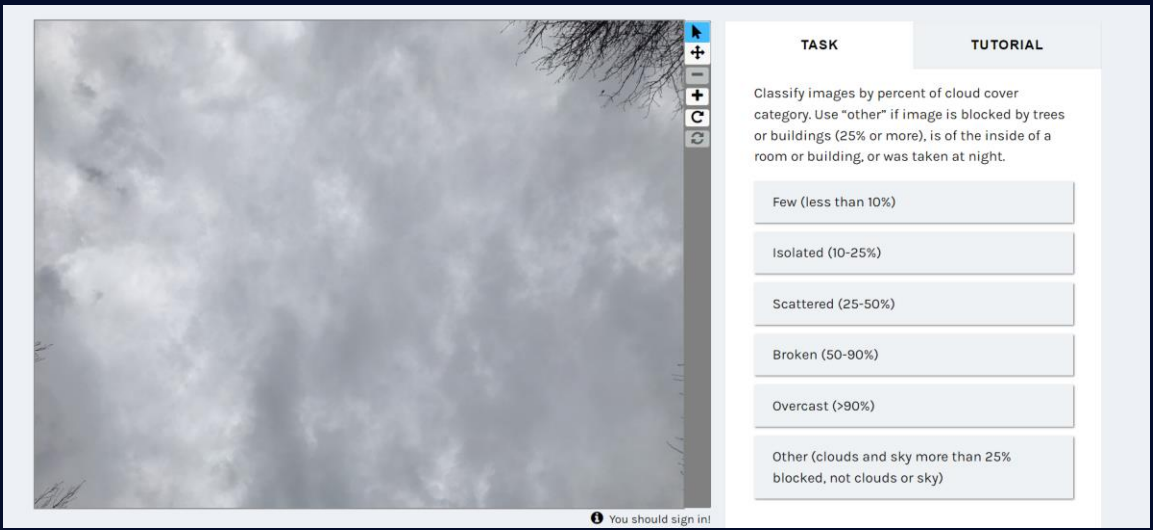


Image: Nasa Globe Cloud Gaze

BOX 7: The project Wildlife Researchers

The project Wildlife Researchers is an urban wildlife ecology project on terrestrial mammals in Berlin (Germany). Participants engaged in an online platform to contribute to research and build a community of citizen scientists and researchers.

https://berlin.stadtwildtiere.de/

Research on the outcomes of the project revealed that participants have developed attitudes toward science but that these were higher in individual participants with prior knowledge on the topic. Future research should thus consider this aspect when evaluating the impact of citizen science initiatives on attitudes toward science (5).

II. **Understanding of the scientific process and how science is conducted (2, 4, 5, 7, 9, 13, 31, 32, 36, 37): Citizen scientists and project initiators/facilitators**

- E.g., knowledge of scientific content, knowledge of scientific methods (i.e., scientific knowledge and scientific reasoning), the ability to discuss and evaluate the origin and quality of scientific results and thus seek answers to scientific questions

III. **Understanding of social, policy and economic processes (CitiMeasure working group): Citizen scientists and project initiators/facilitators**

- E.g., how decisions about wildlife or water resources management are made

IV. **Understanding of technological possibilities and protocols (32): Project initiators/facilitators**

- what are the available tools for a certain type of observation and what are the advantages, limitations, and protocols for use of each tool.

V. **Place-based knowledge directly related to everyday issues (5, 16): Citizen scientists and project initiators/facilitators**

- Local knowledge, e.g., knowledge about species living in a certain area, or how past rainfalls affected a certain neighborhood (3, 8, 20, 28, 32)
- Indigenous and traditional (9, 23, 32 38) including TEK (traditional ecological knowledge) (7, 13, 23, 38)

VI. **Experience with past projects (23, 34): Citizen scientists, project initiators/facilitators and information professionals**

- Volunteers that have some experience in relevant projects will be more efficient in new projects

VII. **Ethics (28): Citizen scientists, project initiators/facilitators and information professionals**

VIII. **Governance principles (28): Project initiators/facilitators**

- understanding of governance principles e.g., fairness, inclusivity, equity, justice

IX. **Legal knowledge (28): Project initiators/facilitators and information professionals**

4.3.3 Attitude

Similarly, eleven main cluster of attitude were identified as relevant for digital inclusion in citizen science. This includes (I) Attitude towards environment, (II) Attitude towards science, (III) Attitude towards citizen science, (IV) Attitude towards technology, (V) Attitude towards society, (VI) Attitude towards policy, (VII) Attitude towards collaboration, participation, and inclusion, (VIII) Attitude towards change, (IX) Self-efficiency, (X) Curiosity, (XI) Moral responsibility. Each attitude category is relevant for one or more of the target groups that were defined in the beginning of this section. Descriptions and references are used to elaborate each attitude category and clarify its source.

I. **Attitude towards environment and human life (5,7, 9, 26, 28, 37)**: ***Citizen scientists and project initiators/facilitators***

- One's perception or ideas towards environment, health, inequality e.g., towards natural resources consumption and management that may lead to pro-environmental behaviour and environmental stewardship, or actions that may harm the environment or human health.

II. Attitude towards science (4, 26, 28, 31, 32, 34, 36, 37): Citizen scientists and project initiators/facilitators

- One's perception or ideas towards science, including general trust in science and actively searching information about science.

BOX 8: The project iSPEX

The project analysed thousands of measurements made during three days in 2013 and combined them into unique maps of dust particles above the Netherlands. Initially, participants had limited involvement with science in their daily live. Through Likert scales, project questions, and Boolean survey questions scholars identified a shift in the attitudes of participants towards science (31).

http://ispex.nl/en/

III. **Attitude towards citizen science (26): Citizen scientists and project initiators/facilitators**

- One's perception or ideas towards citizen science, e.g., the ability of general public to get involved in scientific research and issues such as quality of the data collected or analysed by citizens.

IV. **Attitude towards technology (1): Citizen scientists and project initiators/facilitators**

- Willingness to learn and use technology

V. **Attitude towards society (34): Citizen scientists and project initiators/facilitators**

- One's perception or ideas about social responsibility.

VI. **Attitude towards policy (28): Citizen scientists and project initiators/facilitators**

- Perceptions or ideas about one's ability to navigate the political system, identify political responsibility and accountability, and trust in policy processes, e.g., for unsustainable behaviour, and demand effective policies for sustainability.

VII. **Attitude towards collaboration, participation, and inclusion (28, 36): Citizen scientists and project initiators/facilitators**

- One's perception, ideas or trust about collaboration, collective action, stakeholder participation, or acting for change in collaboration with others (e.g., people from all gender, age, and income groups within the society).

VIII. **Attitude towards change (28): Citizen scientists and project initiators/facilitators**

- Generic perceptions or ideas about changes in behaviour, act according to values and principles, and willingness to discontinue unsustainable practices and try alternative solutions.

IX. **Self-efficiency (28, 47): Citizen scientists and project initiators/facilitators**

- One's confidence in ability to understand certain concepts and processes or take certain measures

X. **Curiosity (34): Citizen scientists and project initiators/facilitators**

- The spirit of discovery

XI. **Moral responsibility (CitiMeasure working group): Citizen scientists, project initiators/facilitators, and information professionals**

- Perceptions or ideas about upholding common values, norms, and principles

4.4 Recommendations

The work of the Digital Inclusion working group resulted in the following recommendations that are relevant for all actors involved in citizen science projects. This includes citizens who (would like to) participate in a citizen science initiative, researchers and information professionals who may initiate, run, or process the results from such initiatives, as well as policy makers, decision makers and municipal employees who engage in these initiatives in different capacities. Everyone has the responsibility to make a CS initiative inclusive.

- **Understand the context** in which a citizen science initiative is being established. Choose appropriate technologies for your participants, based on the social, cultural, economic, and political context (7, 23, 35, 38).
- **Invest time and efforts in the planning phase**:
    - Identify necessary skills for participation, e.g., through brainstorming or mock-up tests (22, 23, 38).
    - Consider privacy, security, legal and ethical concerns from the beginning and work towards resolving those, e.g., by designing appropriate informed consent processes, or anonymizing published data (23, 38).
    - Focus on community gains and make sure participants have the necessary skills and understanding to get the most out of the process (22).
    - Consider the needs for developing new skills in your community, e.g., understanding how sensors work, what data is, and how to interpret it. Spend time and efforts at this stage to train and prepare participants for data collection, interpretation, and resulting actions (22).
- Embed **inclusive thinking from the start** in both project and technology design
    - Aim for diversity and inclusion of marginalized groups including people from different age, race, gender, social orientation, ethnicity, and physical ability strata (6, 7, 23, 25, 27, 29, 32).
    - Carefully consider possibilities for participation of people with different levels of technological savviness by reflecting on how complicated the tasks are, what technical skills are required for participation, and the learning curve of those technological solutions (23).
    - Recognize human values, and emotions (local and global) and shared expectations of inclusion (25).
    - Consider the role, and added value, of traditional knowledge and think about possibilities to capture it. Ensure that this kind of knowledge is likely to feed into decision-making processes. In many situations where citizen-based knowledge and information may open opportunities for achieving a range of ecosystem service safeguards and poverty alleviation outcomes (32).

BOX 9: the Balanngarra Rangers

A collaboration between conservation researchers and indigenous Traditional Owners (the Balanngarra Rangers) enabled the local group to bring their unique skills, experience, and knowledge to the project; an excellent example of the synergy between 'Western science' and Traditional Ecological Knowledge and skills, and the researchers petitioned for more inclusive academic group co-authorship protocols for their resulting research outcomes, with culturally appropriate credit for the contribution of the Rangers (13).

- **Adopt co-creative and participatory design approaches** as this will help identify and overcome end-user challenges from the start (23, 38)
- **Help participants overcome technical challenges** (20)
    - Provide 'easy access' to project information and training. Make sure that 'easy access' is a shared perception by both project initiators and participants (2).
    - Design and run usability tests, for example in form of workshops or surveys (2).
    - Consider different issues related to access to technology (physical, motivational, and actual usage). This includes for example access to internet and smart phone,

motivations to use technology, and restrictions for actual use e.g., due to high usage costs (1, 18, 29, 33, 38).
  - Evaluate new technologies with make-versus-buy and cost–benefit analyses, paying particular attention to reliability and ease of use (7, 35, 22).
  - When possible, adopt well-established, well-documented, and well-supported technologies (7)
  - Consider interoperable, customizable, open-source solutions where possible (7)
  - Follow best practices and use standardized data-collection and data-management protocols where available (7)
  - Encourage use of open-data standards and open-source software (7, 22)
  - Consider support from third parties and organisations to assist with any technology issues, and to keep things running smoothly while sensing is ongoing (22).
  - Provide participants with take home manuals, booklets, guides, and troubleshoot instructions. Experience has revealed that problematic sensors are often abandoned, and people may disengage when the technology fails (22).
  - Partner with local community representatives and ask their help with e.g., training participants, sharing experiences, and coordinating local action. For example, match participants with environmental interests and those with technical skills (22, 38).

BOX 10: the UrbanAirQ pilot

The Making Sense project (2015-2017) explored how local communities can effectively use open-source software and hardware, digital maker practices and open design to make their own sensors. (22). In the pilot UrbanAirQ in the city of Amsterdam, citizen scientists decided what they wanted to measure and why. In this case, they chose NO_2 as an indicator of air quality. The participants raised diverse questions and concerns about air pollution which helped design the approach of the pilot itself.

Image from the Making Sense toolkit

http://making-sense.eu/urban-airq-citizens-measuring-air-quality-themselves/

- **Recognize efforts and create joint identity**
  - Make sure participants' contributions and achievements are recognized, acknowledged, and celebrated as this highly affects attitude towards (continued) participation (2, 7, 13).

    - If desired, citizen science groups should be readily identifiable by an identity and/or agreed upon collective name (13).
- **Be aware of biases** (23, 32):
    - Self-reported ICT skills of individuals may be subjective and based on specific individual experiences (30). Don't dismiss the need for training based on those subjective judgments.
    - When describing needs, knowledge, attitude, and skills, be as specific as possible and realize unconscious bias and ambiguities hidden in terms such as 'enough' or 'etc.' (19).
- **Support learning and capacity building** within participants
    - Support development of skills, knowledge, and attitude amongst participants e.g., via training or by sharing instructions, so participants can learn to use sensors and devices, judge the quality of collected data, understand its (in)validity, and share data via dedicated platforms (6, 22)
    - The setting for providing training needs to match the purpose. E.g., online training may not be the most suitable method for the use of physical devices such as a flowmeter which may need hands-on field skills developed in practice (33).
    - Where possible, partner with local schools and teachers. Jointly develop educational resources around citizen science linked to educational curricula. This helps strengthen science literacy, raising environmental awareness, and transfer certain skills for the use of observation or measurement tools (16, 36).
- Actively try to **emphasise and foster the value of citizen science**
    - Demonstrate the value of citizen-generated data using scientifically sound methods and communicate this with citizen science sceptics at science and policy domains (35).
- **Think about communication and knowledge sharing strategies**
    - The format of communication needs to match the target audience. E.g., visualizations can ensure scientific content is comprehensible for a large target audience and potentially incentivise further engagement (32)
    - Organise events with the aim of knowledge sharing and peer learning (22).
    - Think of possibilities for providing feedback and interactive communication among actors involved (2).

BOX 11: The NEWSERA project

NEWSERA is a H2020 SwafS-19 funded project which aims to demonstrate that citizen science is the new paradigm of science communication. The focus of the pilot workshops is to define citizen science communication strategies addressed to engage citizens. The project thus showcases the virtues of citizen science as an inclusive, broad, and powerful science communication mechanism. NEWSERA established Labs where 38 citizen science initiatives co-design, implement and validate innovative strategies of science communication addressed to a specific stakeholder group from the quadruple helix model (academics, citizens, policy makers and industry).

https://newsera2020.eu/

BOX 12: Find a Lake

This citizen science project at South Denmark University (SDU) involved kids in science in their free time. The main goal was to recruit and educate citizens in collecting data of water quality and insect life to create a dialogue on future research questions. The project designed a detailed communication plan with specific target groups and communication channels (13).

https://www.sdu.dk/en/forskning/forskningsformidling/citizenscience/soer-i-fritiden/find-en-so

BOX 13: The ClairCity project

The ClairCity project sought to incorporate social psychological theories in air quality and carbon management and involved over 818,000 citizens across Europe in six case studies. The project identified demographic groups and social groups in their visuals and communications. It considers science communication as an essential element for the success of these types of projects, tailored communications are particularly powerful, as they enhance credibility and emotional engagement to ensure the facts reach the desired audience The following picture showcases a social card distributed in Bristol, one of the case studies (40).

http://www.claircity.eu/

5. Concluding remarks and next steps

CitiMeasure provided a unique opportunity for representatives of European cities, academia, and (non-)governmental organizations to come together and discuss the issue of digital inclusion in citizen science. Digital inclusion can be studied and discussed using different approaches. The CitiMeasure Digital Inclusion working group chose to use competencies for digital inclusion as a lens for exploring the topic. The result is the prototype of a co-created set of guidelines for digital inclusion that focuses on unpacking types of skills, knowledge, and attitude that may be required for inclusion of citizens in citizen science initiatives and those required by project initiators to establish and run such initiatives. This includes 7 categories of skills, 9 categories of knowledge and 11 categories of attitude, as well as several recommendations on how to enhance such competencies. The recommendations provided in the CitiMeasure Digital Inclusion guidelines build on a wealth of resources and experiences of cities and citizen science projects. Nevertheless, they are not meant to be used as a step-by-step guideline, nor a prescription on how to enhance digital inclusion. Rather, they are meant to be taken as a source of inspiration and best practices and adopting each recommendation should be considered in relation with the context in which a citizen science project will operate, and closely linked to its aims.

This is the first version (prototype) of the CitiMeasure guidelines on Digital Inclusion. Between May and December 2022, these prototype guidelines will be tested in a number of real-life cases of citizen science initiatives. Each case will have a unique pilot plan and based on its context and needs will choose to focus on certain part of the guidelines. The results from the pilot phase will feed into an updated version of the guidelines that is planned to be published in April 2023.

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