SOCIETIC
SOCiety as Infrastructure for E-Science via technology, innovation and creativity

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Version	Date	Author/Editor	Reason for change / issue
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INTRODUCTION

This report contains two documents. First, we present the Green Paper on Citizen Science "Citizen Science for Europe. Towards a better society of empowered citizens and enhanced research" This document is in pre-print version so changes may occur until the printed version. Final version of this Green Paper will be distributed in the ICT2013 event in Vilnius 8th November 2013, and will be published online in the Publications section of the Project Website www.socientize.eu.

The second document presented here gets into the details of the state-of-the art analysis as part of the elaboration of the Green Paper on Citizen Science. It is an extension to the short version of the Green Paper on Citizen Science, providing interested parties with more in-depth information and discussions that led to the Topics, open questions and recommendations of the Green Paper.

1. GREEN PAPER ON CITIZEN SCIENCE

socientize
citizen science projects

Green Paper on Citizen Science

Citizen Science for Europe. Towards a better society of empowered citizens and enhanced research

European Commission

This is a pre-release which after further layout formatting will be printed as an SOCIENTIZE publication

Executive summary

Citizen Science is gaining a renewed impulse thanks to the digital revolution. Broadly understood as the general public engagement in scientific research activities, citizens add value and contribute to science both with their intellectual effort and surrounding knowledge sharing as well as with their digital tools and resources. It represents an effective scenario for many of the values of the Europe 2020 strategy and becomes relevant across many of the topics of the imminent Horizon 2020 programme, presenting potential links with other EU programmes. Outcomes of this participatory approach vary in a wide range of values in scientific, social, economic, educational, environmental and inspirational levels.

The SOCIENTIZE Consortium is coordinating an ongoing public consultation and debate about the potential role of Citizen Science in Europe. As an intermediate result, this Green Paper presents the major themes of discussion and some of the policy recommendations that will be refined within the further White Paper on Citizen Science.

Section 1 presents the background, purpose and scope of this Green Paper.

Section 2 presents the opportunities for strengthening citizen involvement in research in Europe. We analyse and align Citizen Science within Europe 2020 strategy, and the EU Framework Programme for Research and Innovation. Section 3 presents the activities and methodology followed for the observation and diagnosis of Citizen Science in Europe, including profiles of involved stakeholders and topics discussed. We give a short overview of the state of the art extracting common features of the whole range of Citizen Science projects. Section 4 analyses key elements of Citizen Science and major discussion themes among the interested parties. Those major themes are the following:

1. Definition and scope of Citizen Science, supporting different engagement models and understanding the potential, suitability, risks and linked policies implications
2. Deployment, facilitation and sustainability for Citizen Science projects and coordinated activities at local, national and European scale
3. Awareness and motivation for active involvement of researchers and volunteers, developing understanding of the related challenges
4. Openness, technologies and cultural shift for sharing of data and techniques among stakeholders amplifying collective intelligence
5. Impact measurement and evaluation of the different outcomes based on trusted indicators and emerging public debate upon efficiency and excellence in science

Each section provides a description of the topics and relates these to a set of open questions. A number of success stories are interwoven to exemplify good practice.

Section 5 briefly presents a concrete set of policy recommendations, provided by the SOCIENTIZE Consortium and other interested parties. Grouped under the same major themes described in Section 4, these possible measures include strategic and operational improvements forming the starting point for further discussion and refinement. Their impact depends on policy initiatives adopted on local, national and EU level. SOCIENTIZE Consortium believes that these policy recommendations could be considered by the Commission’s for further funding schemes and calls within Horizon 2020.

Section 6 explains the plan and roadmap for the next steps in the consultation process. It will include further online open consultations and public events, like endorsement and debate

workshops based on this Green Paper. The final goal is to create a White Paper on Citizen Science in Europe by September 2014.

1.1. Purpose and scope of the Green Paper

This Green Paper aims to foster the interaction between the Citizen Science stakeholders and the EU policy officers, reinforcing the culture of consultation and dialogue in the EU. Interaction between the European Institutions and society takes various forms, primarily via the European Parliament, via institutionalised advisory bodies of the EU and via less formalised direct contacts with interested parties. In this later approach, this document is delivered by the SOCIENTIZE Project to the European Commission's Digital Science Unit as part of the activities carried out under contract number RI-312902.

This report is the result of the coordination, support and networking activities carried out during the first year of execution of the SOCIENTIZE Project. This document serves as a facilitator of further debate, discussions and feedback, community endorsement, mutual learning and exchange of good practices within the stakeholders. Initially conceived as a draft White Paper, many organisations expressed a desire to supply more detailed comments and country-specific recommendations. The SOCIENTIZE Consortium, therefore, decided to publish this Green Paper in the form of a consultation document, encouraging all interested parties to submit their experiences on citizen engagement in science and get wider discussion and endorsement during the second year of execution of the SOCIENTIZE Project. As a result, the White Paper on Citizen Science will be created, published and distributed by September 2014.

Wide consultation is not a new phenomenon and the EU Commission has a long tradition consulting interested parties from outside when formulating its policies. Thus, the benefits of being open to outside input are already recognised. The approach of this Green Paper adopts involvement of interested parties through a transparent debate by performing consultations in a meaningful and systematic way. General principles include participation, openness, completeness and clarity.

The SOCIENTIZE Consortium would like to express its gratitude to the large number of people who gave their time freely to contribute information, endorsement, and insight to this Green Paper. Both the quantity and the high quality of the various contributions show the clear interest of outside parties in Citizen Science in Horizon 2020. There is a list of all contributors in the Annex II.

More information on the SOCIENTIZE Project website http://www.socientize.eu

1.2. Citizen science in the European policy context

"In the debate that is ongoing all across Europe, the bottom-line question is: Do we want to improve Europe or give it up? My answer is clear: let's engage! If you don't like Europe as it is: improve it!"

José Manuel Barroso, President of the European Commission to the European Parliament, 11 September 2013

1.2.1. Citizen Science alignment within Europe 2020 strategy

Europe has traditionally a clear leadership role at the vanguard of democracy and research advances, and Europe is nowadays facing social, scientific and policy challenges. In the last years, the economic and social context has changed and Europe is now urged to stabilise the economic situation in the short term while also taking measures to ensure growth opportunities of tomorrow.

In 2014, Europe will adopt the new Europe 2020 strategy with three key priorities: smart growth sustainable growth and inclusive growth.

Europe 2020 Flagship Initiatives	**and its alignment with Citizen Science**
Digital Agenda for Europe	aims to re-boost Europe's economy and help citizens and businesses to get the most out of digital technologies.
Innovation Union	recognises European unique set of values and strengths in design, creativity, services and the importance of social innovation.
Youth on the move	highlights that learning isn't limited to schools and plenty of learning happens also outside the classroom.
Resource-efficient Europe	supports the shift towards a sustainable growth based on using existing resources more efficiently involving governments, stakeholders and the European public.
An industrial policy for the globalisation era	places innovation in the centre stage of growth. A competitive public science base will drive curiosity-driven research, bottom-up and forward-looking activities which will improve European position tackling societal challenges.
Agenda for new skills and jobs	Volunteers develop new skills, scientific-technological knowledge, STEM background and beyond .
European platform against poverty and social exclusion	aims to remove barriers in education between other policies. Citizen Science puts a hook on self-learning for risk-of-exclusion citizens.

While this Green Paper focuses on research and innovation, there are important links to other EU programmes, notably to the structural funds for cohesion policy and education programmes.

1.2.2. Citizen science in European funding programmes

The imminent Horizon 2020 funding programme for research and innovation sets three strategic objectives: excellent science, industrial leadership and societal challenges. These major topics lead the breakdown of the Horizon 2020 agenda which will:

- support most talented teams to carry out frontier collaborative research and innovation.
- open up new and promising fields of research.
- provide researchers excellent training and career development opportunities.
- ensure world-class research infrastructures accessible to all researchers in Europe and beyond.

Citizen Science becomes relevant across these topics. Other Citizen Science related topics included in Horizon 2020 are:

- Deepening the relationship between science and society
- Reinforcing public confidence in science
- Informed engagement of citizens and civil society on research and innovation
- Promoting science education
- Making scientific knowledge more accessible
- Responsible Research and Innovation (RRI) agendas that meet citizens' and civil society's concerns
- Facilitating participation in Horizon 2020 activities

ICT will support the leadership from research to market uptake and for public procurement. A challenge-based approach will bring together amateur and professional resources and knowledge across different fields, technologies and disciplines.

One of the new features of Horizon 2020 is the simplified and integrated approach, allowing more possibilities for new excellent researchers to address the societal challenges through proposals which allow plenty of scope for applicants to propose innovative solutions on their own choice.

The European Commission can play a coordinating role by identifying best practices and promoting new 'smart' solutions for enhanced research and social innovations, supporting these through national and European funding.

1.2.3. Citizen science as an element of Digital Science and Responsible Research and Innovation

The Digital Agenda of the EU is managed by the European Commission Directorate General for Communications Networks, Content and Technology (DG CONNECT). In DG CONNECT, a new term "Digital Science" has been adopted in order to promote excellent science in the context of the Digital Agenda, Digital ERA and Horizon 2020. This new term refers to the ICT-enabled radical transformation of science and innovation within a culture of openness and sharing. Digital Science is more open, global, collaborative, creative and closer to society. One of its basis are the e-infrastructures, services and tools for data and computing intensive research in virtual and collaborative environments.

Horizon 2020 aims to mainstream Digital Science and all the projects will be encouraged to embrace, when appropriate, measures like open access mandatory clause or science-society interaction. Digital Science 'objects of enquiry':

- Technologies and components for data gathering and networked systems
- Models, methods and tools for information processing
- Platforms and infrastructure which support collaborative research
- Innovations on the related challenges

ICT facilitates a shift of paradigm, with a more open research process sharing good and bad experiences through digital media and collaboration efforts.

> In Citizen Science, participants contribute to science in two ways:
>
> - with their intellectual effort and surrounding knowledge sharing
> - with their digital tools and resources

These new participative and networked relationships promote the transformation of the scientific system, allowing collective intelligence and new collaborative knowledge creation, democratizing research and leading into emergence of new disciplines and connections to study emerging research questions and topics. While doing this, participatory approaches contribute to long-term inclusive education, digital competences, technology skills and wider sense of initiative and ownership.

> Citizen Science adds value to Excellent Science related calls within Horizon 2020 like Future and Emerging Technologies, Open and Support Actions, Global Systems Science, e-Infrastructures, Data Infrastructures, Virtual Research Environments and Policy Support Actions

The Directorate General for Research and Innovation (DG Research and Innovation) is also determined to bridge the gap between the scientific community and society at large. The current "Science in Society" programme is transformed in "Science with and for Society" sustaining a two-way dialogue between researchers and civil society. One of the challenges is the Responsible Research and Innovation (RRI). With the focus on products and services to achieve a social environmental benefit, it includes areas of activities related with public understanding of and engagement in science, formal and informal education, ethics governance or open and free access to publicly funded research results among others.

> There will be specific calls on RRI issues like science education, governance for RRI, or integrating society in science and innovation with aspects such as Citizen Science, collaborative scenario building or knowledge sharing support.

Environmental Sciences and Computational Social Science

Besides environmental sciences where experiments produce the necessary data, social systems constitute a major challenge because of the heterogeneous approaches of different science disciplines. Progress can be done by combining computational and experimental approaches and open data is crucial for reproducibility of results. Examples of Science-Society-Policy systems related with Citizen Science:

- Citizen observatories, developing community-based environmental monitoring and information systems using innovative and novel earth observation applications
- Global systems science, combining advanced ICT and citizens dialogues to understand and shape global systems. GSS produces evidence, concepts and doubts needed for effective and responsible policies dealing with global systems.

1.2.4. European value and context of Citizen Science

Citizen Science in Europe is embedded in a complex environment formed by many heterogeneous interacting groups with different levels of public engagement in science. Some cases are related to private funding, others are linked to science museums, others are dependent on European, national, regional or local public funding support. Stakeholders form a network with hierarchical connectivities in multiple scales and non-local interactions. We have compiled experiences of local and international initiatives which status and their evolution depend sensitively on each context-specific conditions. Moreover, policy aspects merge with scientific, educational, social and inspirational values. In these changing environments, transdisciplinary agents tend to cross boundaries fostering cultural changes and growth at European level.

Broadly understood as the general public engagement in scientific research activities, it is hard to describe Citizen Science in terms of a few variables. It covers a wide range of approaches with different goals and involvement models. In any case, we must understand Citizen Science as a concept and a way of thinking, instead of a restrictive tag.

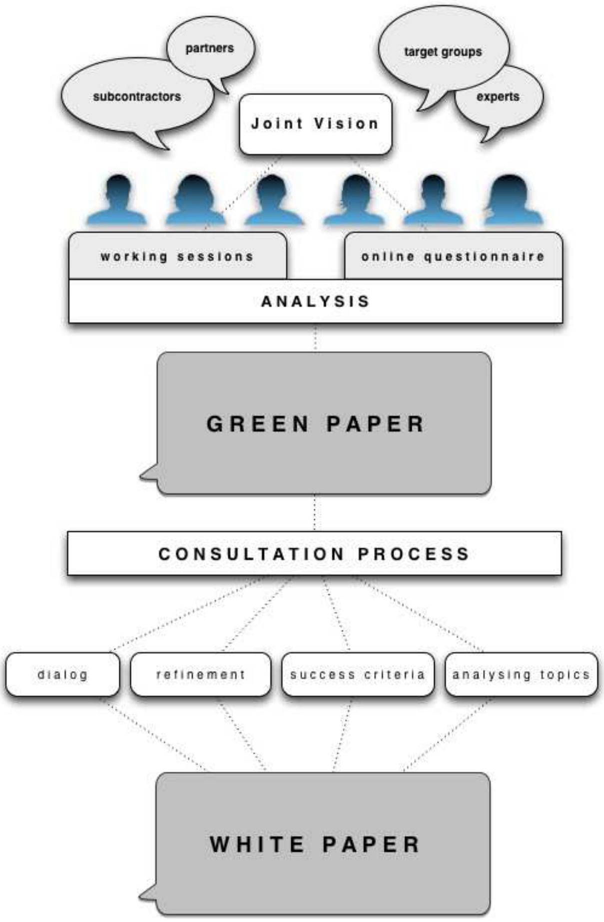
In the context of European heterogeneity and global challenges, central planning and national regulations must be completed with an intricate set of measures making the performance more predictable. Policy makers could increase the efficiency of the EU-wide activities by using appropriate regulations such as funding programs and social arrangements. Openness, dialogue with positive and negative feedbacks, checks and balances on every level must be ensured. These policies may be triggered by ICT-based grassroot approach allowing effective data and opinion collection and real-time information spreading processes.

Undoubtedly great progress is being made, and European scientists are playing a leading role in this field. Despite Citizen Science is still in its infancy, which makes some promises highly risked, ICT will continue to foster and accelerate huge advances.

1.3. SOCIENTIZE approach to developing a common roadmap for citizen science in Europe

Citizen Science has gained wider institutional, political and public attention only rather recently. However, the concept of civic participation and the involving of citizens in the scientific process has a long tradition. In order to capture the current state of affairs and diagnose the most urgent issues a mixed-method approach has been chosen.

The following image gives a broad overview of creation process:



As the image shows the methodology followed the SOCIENTIZE consortium is a combination of different phases:

- **Exploration, observation and analysis**: identification of current state from literature and in dialogue with consortium members, External Advisory Board (EAB), subcontractors, external experts and other stakeholders. Aim of this phase: identification of common features, crosscutting concerns, shared issues, correlations, patterns.
- **Mapping and prioritization**: identification of common elements, key factors and challenges, as well as open issues.
- **Policy recommendations**: Definition of a first set of possible policy recommendations at strategic and operational level based on the previous step
- **Consultation, feedback, review and endorsement:** first round of consultation with specific stakeholders and revision of open issues

- **Publication of Green Paper:** the publication of the Green paper initiates the next step of wider consultation
- **Next steps**: wider consultation, endorsement, complete issues, countries specific issues, white paper

Applied methods and main sources of information

As a first step a traditional approach of state-of-the-art analysis in the form of desktop research was performed in order to synthesize the current knowledge based on Citizen Science. A complete version of this document is available on the SOCIENTIZE website (http://www.socientize.eu/).

The elaboration of this document depended also heavily on the contribution of different stakeholders and key informants on the topic. Collecting input from the experts has been organised in different steps. Semi-structured interviews were conducted remotely with a first set of key experts.

In parallel, an open consultation process has been launched online. The call for contributions is still open and is accessible for any interested citizen. With this completely open approach, we intend to collect experiences and suggestions from the diverse stakeholders involved in Citizen Science, like volunteers, researchers, infrastructure providers, scientific organizations, communicators, innovators, journalists, educational experts and artists.

In a second step, after having analysed and summarized the main outcomes from the interviews, the state-of-the-art analysis and the open consultation contributions, a first interactive session has been organised with an extended group of experts. Experts met during a 2 h online workshop to reflect on the identified open issues.

Additional input for the current state of affairs has come from a continuous monitoring of Citizen Science projects, own participation and execution of Citizen Science projects, the screening of a wide range of position papers on the future of EU research and innovation and additional informal discussions with interested parties.

Involved Stakeholders

In order to cover the broad spectrum of Citizen Science and allow for a diversity of opinions and approaches, the group of targeted stakeholders during the process so far has been defined very broadly. It includes especially the following groups: General public, local communities, civic society organisations, students, risk-of-exclusion groups, teachers, educators, developers, makers, infrastructure providers, artists, journalists, communicators, policy makers, companies, museums, open living labs, researchers, all of them both amateur and professionals.

Topics covered

Cultural change, engagement of citizens and scientists, openness, curricula, motivational aspects, organisational and structural challenges, limitations, definition and scope, tools, standardization, collective intelligence, business responsibility, educational responsibility, training, responsible research and innovation, quality assurance, methodologies, sustainability, governance, funding, evaluation and impact measurement.

1.4. Proposed focus points for citizen science roadmap

SOCIENTIZE has determined 5 major themes of discussions based on the relevance for the different Citizen Science actors and policy makers:

- Definition and scope of Citizen Science which support different engagement models, understanding the potential, suitability, risks and linked policies implications.
- Deployment, facilitation and sustainability for Citizen Science projects and coordinated activities at local, national and European scale
- Awareness and motivation for active involvement of researchers and volunteers, developing understanding of the related challenges
- Openness, technologies and cultural shift for sharing of data and techniques among stakeholders amplifying collective intelligence
- Impact measurement and evaluation of the different outcomes based on trusted indicators and new public debates upon efficiency and excellence in science

1.4.1. Definition and scope of Citizen Science

The term Citizen Science has been used to define a series of activities that link the general public with scientific research. Volunteers and non-professionals contribute collectively in a diverse range of scientific projects to answer real-world questions. Both citizens' contributions and researchers' attitudes encompass a wide set of activities at multiple scales. We find massive occasional interactions at global scale virtually but also regular proactive involvement in local environments identifying new research questions. In addition, the level of engagement vary widely from person to person and may also change over time and experts recommend strategies to offer different levels of engagement.

In this context many classifications provide categories for different degrees of participations, approaches and goals. However, the majority of projects adopt similar methodologies, and consider the data gathering and interpretation as the most important aspect, allowing reality-mining used to verify or improve their models more efficiently. There is a demand for more involvement of the volunteers and the establishment of partnerships on equal terms between scientists and citizens, addressing relevant issues of today's society. Digital sharing, online projects and social networks offer new ways to gain acceptance among scientific community and society.

Cross-cutting aspects of Citizen Science

problem definition, interdisciplinarity, social value, scientific impact, awareness, reluctance, motivation for engagement, science-society-policy debate, funding resources and sustainability, digital resources, methodology, modeling, thoroughness, quality assurance, report results, reproducibility, privacy and IPR, evaluation, recognition, education and training, inclusion, accessibility, feedback, interaction and information, unpredictable group dynamics, design, emotional aspects

Citizen Science actors must be aware of its potential and risks when determining the engagement level and suitability of this participatory approach for any given scientific problem. When designing a new Citizen Science project or participatory experiment potential risks must be addressed as well as the challenges in marketing and funding mechanisms.

Different categories:	**Different levels:**
collaborative science crowd-crafting participatory experiments collective intelligence volunteer thinking volunteer sensing volunteer computing human sensing	Local Regional National European Global Virtual

Open questions:

1. Should there be a specific definition of Citizen Science officially adopted by the EU? If yes, how broad should it be? Should it support all levels of Citizen Science?
2. Should only research-driven systematic projects be considered within Horizon 2020? How to promote and support citizen-driven projects?
3. How may the level of volunteer involvement change over time and what does this mean for Citizen Science projects and programmes?
4. How to efficiently support both local and European initiatives?
5. What is the European value of Citizen Science projects?
6. How to encourage intellectual revolutions adopting different approaches and methods?
7. How to promote private partnerships / industry innovations? How to include non scientific disciplines approaches (politics, arts, amateurs…)?
8. How could Citizen Science decrease the perceived distances between policymakers and volunteers?
9. What are the possible risks, security issues and constraints of Citizen Science?

European perspective:

- Should there be a specific definition of Citizen Science officially adopted by the EU? If yes, how broad should it be? Should it support all levels of Citizen Science?
- What is the European value of Citizen Science projects?
- What kind of balance should be reached between the support for research-driven systematic projects and citizen-driven projects within Horizon 2020?

Societal perspective:

- Does Citizen Science make a clear impact on the life of citizens?
- Should there be more emphasis on citizen-driven projects?
- What are the possible risks, security issues and constraints of Citizen Science?
- How could Citizen Science decrease the perceived distances between policymakers and volunteers?

Operational perspective:

- What is the role of Citizen Science enhancing excellent science? How can it contribute in policy decisions?

- How may the level of volunteer involvement change over time and what does this mean for Citizen Science projects and programmes?
- How to efficiently support both local and European initiatives?
- How to promote and support citizen-driven projects?
- How to encourage intellectual revolutions adopting different approaches and methods?
- How to promote public private partnerships/industry innovations? How to include non-scientific disciplines approaches (politics, arts, amateurs…)?

1.4.2. Deployment, facilitation and sustainability models

Citizen Science has a long history and tradition, but experiences considerable expansion in the last years due to changing science paradigms and the increased usage of innovative technologies, effectively utilizing crowdsourcing for data collection over large geographic regions and bridging volunteers' and researchers' world. To facilitate this growing movement Europe requires both top-down and bottom-up approaches allowing local groups and international networks to deploy and support new initiatives.

In order to underpin European structural problem drivers, policy programmes must ensure sufficient contribution for research and innovation to tackle societal challenges, promoting technological leadership and innovation capability. There is a need to strengthen the science base and critical sense. Education at universities for scientists and students in advanced statistical techniques and computational models, providing students with insights on how to collect, validate and handle huge Citizen Science data sets and how to set up and conduct Citizen Science projects, was identified as another facilitation aspect.

Despite the general notion of low-cost research, Citizen Science projects require a wide set of profiles in the organizations. Professionalization may increase the productivity but individuals may provide excellent ideas. Networked initiatives need dedicated teams for Citizen Science dissemination, organization of events but also to provide technical support even when adapting scientific models or managing data, and even understanding the volunteer dynamics.

The long-time sustainability and funding of Citizen Science projects is a challenge for all types of Citizen Science projects. Issues of prioritization and sustainability raise the question of how government funding and partnerships might help sustain public interest in doing science for society.

Most of the Citizen Science projects stand on public funding. Crowdfunding Citizen Science projects is currently considered as an alternative funding strategy. There is however a fear associated with this approach in terms of who is deciding on what research should be funded. Such an open approach might intervene too much in the scientific process. The challenge here is to find the balance between openness and involvement on the one hand and keeping the original idea of the specific research project on the other hand. Selling advertising space on Citizen Science websites is considered another funding model, but there is strong worry that this would devaluate the project.

"An economic analysis of the relative costs of different forms of computing is needed. With volunteer computing you can do more computing for less money".

David Anderson (Space Science Laboratory, University of California, Berkeley; project director of BOINC)

There are also economic factors in favour of externalizing resources but it still requires a deeper economic analysis of relative costs of different forms of Citizen Science compared with other e-infrastructures.

Open questions:

- What is the role of cluster initiatives and Citizen Science associations? How to balance the visibility and funding to the end-users? On which level do we need these initiatives (European, national, regional)? How could they best cooperate?
- How to share services (e.g. log accounts, workflows, collaborative tools, communication…) among different Citizen Science initiatives?
- What are the most important services these organisations should provide (e.g. practical support and guidance for setting up Citizen Science projects, etc.)?
- What kind of funding mechanisms do we need in the Horizon 2020 to support Citizen Science projects and their sustainability? Should the EC launch specific calls for Citizen Science support?
- Is there a need for new sustainability and funding models? Are there good practices to follow within the EU?
- How to fund in the long term large infrastructures for huge, dispersed and persistent data sets?

1.4.3. Awareness and motivation for active involvement

Attracting and retaining people who would be willing to contribute their skills, time, and effort for a scientific cause is an important pillar of Citizen Science work. Motivational drivers and barriers for both scientists and volunteers are diverse and depend on the project type but also on the context in which volunteer engagement is taking place. While in some contexts providing valuable contributions to science or to the local community might be the most important motivational driver for citizens' involvement, in other contexts it might be monetary incentives, as only financial aid would render the participation possible for some participants. Intrinsic motivators, like the interest in the scientific topic or the satisfaction from contributing to science, have been identified as being amongst the most important drivers for volunteers' participation. But when a preferably large number of citizens should be involved over longer time spans in Citizen Science projects (that might be less intrinsically motivating), external motivators, like community recognition, competitive elements, or incentives come into play. Volunteers' motivations are said to be temporal, dynamic and changing even when the ultimate goal remains the same. Physical spaces devoted to Citizen Science and face to face meetings are understood as effective tools to improve community aspects, easing social interaction, media coverage and emergent group dynamics.

The initial phase of involvement, when volunteers need to understand the projects' objectives and opportunities for contribution, has been identified as the most critical one. The majority of volunteers only perform activities one day and do not return to execute more tasks, so the regular minority contribute for the larger proportion of tasks carried out in the project. Media coverage, approaching existing institutions, using social networking features, but also collecting first positive hands-on-experiences with science are potential drivers. Once volunteers are involved the next challenge is keeping them engaged. This requires finding out what motivates them in the long run, but also continuous personal information flows between the involved stakeholders and well adapted and interesting tasks are important.

The involvement of citizens in scientific projects tends to have an educational value, implicit or explicit. While in the majority of projects the informal learning aspect of adult citizens is addressed, schools are more and more considered an important target for the introduction and promotion of Citizen Science. Teachers play a relevant role easing the deployment of experiments and transmitting the socio-scientific values of their contributions to the young audience.

> *“ I see great potential in Citizen Science projects to attract young people into science if they are approached at the right time. The educational goal of Citizen Science is most exciting”*
>
> *Ben Segal (honorary staff member at CERN, member of Citizen Cyberscience Centre)*

Motivational issue do not only consider volunteers, they are also relevant for the involvement of scientists. Involving non-scientists, new scientific areas, and engage long-tail researchers in Citizen Science will promote new research advances. In this multi- and inter-disciplinary context, we find barriers like vocabulary, practices, meanings, but also competencies, mutual recognition, and prestige. Establishing trustful, balanced collaboration between these groups is not always an easy matter and must be encouraged also through non-academic means. It is said that in many institutions there is still a lot of resistant scepticism amongst researchers. Scientists need to understand that Citizen Science is committed to authentic and enhanced research which can bring viewpoints and perspectives not otherwise available to science. It takes an additional effort to redefine their models and assumptions, and interacting with volunteers is time consuming, but it opens new sources of data, decreases costs in infrastructure deployment and operational and opens the door for new funding opportunities.

Scientific values and opportunities
Large sets of existing and connected resources, with enormous granularity in space and time
Large local and reality knowledge provided by amateur also providing valuable feedback and collective ideas
Large experimental datasets and digital footprints
Existing mature e-infrastructures and open technologies allow efficient management of data

and virtual environments for creating multidisciplinary and global research groups
Potential in scientific dissemination about research and policy issues
New ways of greater recognition and impact

Open questions:

- What are the motivational drivers and barriers related to different types of Citizen Science projects and how do they change over time?
- How to increase awareness and linkages among all the actors considering their roles and motivations? How could the involvement of citizens in research be best disseminated and motivated amongst researchers?
- Do we need any expert help (publicists, psychologists, etc.) to find the "real" motivations of people?
- How could we best support Citizen Science in schools and what role are teachers playing? Should we address younger audience in primary schools?
- How to make the most of the differences on conditions in Europe (investments, social culture, technologies adoption, legislation…)? How to avoid that those citizens who don't have access to technology are excluded?
- How should Citizen Science be addressed in the academic curriculum at different levels (primary and secondary education, undergraduate and graduate level, etc.)?
- How to engage more volunteers in the scientific problem definition?

1.4.4. Openness

A cultural change is happening at global scale through inspirational success stories of collaborative open-minded approaches breaking the walls of disciplines with transdisciplinary strategies. Openness improves speed, efficiency and efficacy of science policy, allowing researchers and general public faster access to the information. Open Access is gaining acceptance as the research impact of OA journals and awareness among researchers grows in the last few years.

Openness in the context of Citizen Science relates to the software used as well as to the data gathered. Current projects are based on proprietary software as well as on open source software with a clear trend towards openness. There is a claim by some experts in the community that Citizen Science platforms and software should be free to use and preferably open source, as this would best fit the initial idea of voluntariness, openness and collaboration.

Openness is an issue for the future of Citizen Science, also when it comes to access and interoperability of the Citizen Science data sets. Large data sets based on Citizen Science data have been created by scientists for their own needs and are often difficult to be used by other groups, like citizens or researchers. In addition, there is a claim that public authorities and companies provide open access to their data as well in order to be used by citizen scientists for their research and also increase interoperability between these data sets. When opening the data sets, the important question of ownership and IPR issues arises. A frequent issue for scientists who work in Citizen Science projects is that they do not want to share and provide access to the collected data. When companies as sponsors are involved it might even complicate this issue. Only few projects have a clear policy about the ownership of the results, and especially volunteers are hardly informed about the intellectual property rights of projects they have been involved in. Hardly any regulations are foreseen for the use of the data by third parties. Experts require a political decision regarding the access to scientific data.

Regarding interoperability of data, there have been first efforts in the United States to synchronise data amongst data sets, but these efforts are still in the very early stages. That's why one of the biggest goals is that people working in this field define data standards that all Citizen Science projects can use.

Open questions:

- Should Citizen Science only use open source software?
- Should there be open access and interoperability between Citizen Science datasets and/or public data?
- Is there a need for standards in terms of used technology and interoperability?
- Does openness increase confidence in and validity of Citizen Science findings?
- Is there a need to improve privacy regulations and IPR issues with regards to data usage and ownership?
- How can the awareness of potential scientific value be improved and compared to established scientific approach?
- Is there any effective anonymization technique for privacy data sharing?

1.4.5. Impact measurement and evaluation

Horizon 2020 smart investment must be excellence-based but new trends in science need nurturing from infancy to maturity. Citizen science generates a diverse set of outcomes for science, individual participants and socio-ecological systems, which determine the success of a project. In the core of all Citizen Science projects is the scientific progress, next to advances in individual participants and local communities/societies as well as educational benefits. The degree to which the divers outcomes are realized depends on the type of the project and its objectives. As a complex collective activity, in Citizen Science the total is more than the sum of the parts and overall performance depends on researchers excellence, technological equipment and their networking capabilities, notably commitment and interactions with society.

The involvement of citizens helps to collect and analyse data that could not be treated any other way easily and makes use of computing power, time, cognition and human perception from volunteers to support the analysis of data. It allows gathering large volume of field data on large geographic scales or long time spans. Citizen science provides new opportunities to widen the scope of traditional projects, combining natural systems together with social data. It has the potential to better investigate and understand how society and culture influences environmental issues and how these systems are dynamically interlinked with each other. The challenge is here to disconnect from traditional ways of conducting science and thinking about new opportunities for innovation and insights that lies at the interface of science and society and in the links between disciplines.

Different motivations:	Different outcomes:
Scientific	publications, findings, critical mass
Economic	low-cost, crowdsourcing, innovation, actions,
Social	legislations, relationships, conservation,
Environmental	sustainability, consciousness
Educational	skills, knowledge, empowerment
Inspirational	debate, emotions, identity, ownership

Projects that directly involve members of the public in scientific research seem particularly suitable for increasing participants' awareness, content and scientific knowledge as well as some changes in attitudes towards science and in behaviour related to the topic under investigation. Studies which investigated the knowledge increase amongst volunteers stress the importance of collaborative and co-created projects as well as projects which cover a broader spectrum of activities for volunteers to make learning amongst citizens more robust.

> *"We should promote the next phase of Citizen Science as "Crowdcrafting" where citizens make projects with the help of scientists, not only for the benefits of professionals but for the benefits of society, a rather citizen-driven research".*
> *Francois Grey (coordinator of the Citizen Cyberscience Centre)*

In action-oriented and conservation projects scientific knowledge supports local initiatives to provide evidence for interventions influencing in policy decision-making. An increasing number of literature points out to the benefits of combining scattered local and practical knowledge from communities with the scientific work. To better understand the contribution of Citizen Science to science and society, advanced measurement tools and assessment scales are required in order to evaluate and compare the outcomes and effectiveness across multiple Citizen Science projects.

Open questions:

- Would a standardised impact measurement across multiple European Citizen Science projects foster the larger expansion and acceptance of this approach?
- Who should be the actors to create these measurement tools and assessment scales?
- How to promote more bottom-up projects requested by citizens?
- How to measure balanced scientific, social and educational impact?
- How to ensure efficiency and added value to the public contributions?
- How to decide to follow up a Citizen Science project?
- How can we extract and recognise additional values of Citizen Science, such as ready access to information, transparent and responsive procedures or flexible working arrangements?

1.5. Policy recommendations

The set of open questions presented in the previous section group the issues discussed with the stakeholders during the first year of the SOCIENTIZE project in five major themes. In order to facilitate the debate about how Citizen Science can help Horizon 2020 to reach its goals, we present in the following a set of policy recommendations required to achieve the proposed goals, based on contributions and discussions held with the different interested parties.

The SOCIENTIZE Consortium believes that these policy recommendations should be considered in further policy developments and funding mechanisms.

1.5.1. Definition and scope of Citizen Science

- Define clearly the scope of Citizen Science and its participatory model, adopting the implications of the definition on the support measures taken by the EU for Citizen Science.
- Catalogue and align the funding mechanism related with Citizen Science.
- Identify and catalogue the agents, initiatives and stakeholders and their profiles, analyzing their relationships and promote coordinations.
- Enhance public debate and decision-making processes on science challenges and policies.
- Promote synergies between the Horizon 2020 programme and the national funding mechanisms, optimising individual strengths of every region.
- Promote teams of Citizen Science institutions of different regions, including excellent research institutions and low performing or late adopters.
- Advise the public authorities at national and regional level to benefit from the insight of international initiatives.

1.5.2. Deployment, facilitation and sustainability models

- Promote Citizen Science in Horizon 2020 by e.g. reflecting it in the funding schemes, setting a list of requirements for the Citizen Science projects, launching specific calls, and favouring projects that include Citizen Science aspects.
- Support structured partnerships and international networks of cooperation for researchers, innovators and citizens to jointly develop and implement Citizen Science agenda, with strategic roadmap and actions.
- Support both Citizen Science associations for offering specific services to the community and researchers groups for implementing success stories.
- Promote the upscaling of regional successful initiatives in order to validate models.
- Give more publicity to the funded projects.
- Promote the design and definition of sustainability models for Citizen Science projects with long-term commitment for infrastructures and data repositories.
- Proactive awareness raising amongst researchers to perform Citizen Science, making explicit the importance of involving different stakeholders e.g. civil society organizations.

1.5.3. Awareness and motivation for active involvement

- Design and promotion of new researcher reputation systems and definition of incentives for interaction with citizens, such as recognition in appraisal and tenures.
- Promote public spaces and events in Europe specifically promoting Citizen Science initiatives and teaming with science festivals and science museums, open laboratories and citizens communities.

- Increase the participation of the society in the meetings organized about Horizon 2020.
- Encourage knowledge exchange and public interaction through non-academic means e.g. artistic performance, storytelling, film making… Consider an operational scheme to include all the interested parties in funded projects
- Support inspirational projects which can lead to breakthrough research and innovation based on the collective intelligence.

1.5.4. Openness

- Promote cultural change and new scientific culture by increasing the benefits for researchers, public institutions and industry of opening, sharing and co-creation.
- Promote democratic governance of science via public engagement and debate between policy makers, researchers, innovators and the general public in a structured channel for feedback and open criticism.
- Encourage resources sharing including access to journals, methods, data, tools, and equipment akin to open science.
- Promote the creation of appropriate tools as well as standards for interoperability, metadata, citations, anonymization, accessibility...
- Define governance structures regarding data ownership and usage.
- Adopt Open Source and Open Access policy, developing a set of indicators to measure open access.

1.5.5. Impact measurement and evaluation

- Launch a tender to create a standard set of impact measurement toolbox that should facilitate the impact measurement of any Citizen Science project.
- Ensure that all Citizen Science projects financially supported perform impact measurement.
- Ensure that best practices are shared among public funded projects
- Consider an organisational structure to facilitate general public evaluation of science policy and public funded projects
- Reform researcher evaluation methods, adapting science evaluation and ranking methods.

1. 6. Next steps and roadmap

The creation of the White Paper on Citizen Science will be based on a second round of broad consultation, where the wide range of stakeholders will be invited to participate and debate on the basis of the first relevant topics, open questions and policy recommendations of this Green Paper, which will be spread in digital or paper format amongst all the interested parties.

A continuous dialogue with partners, subcontractors, citizens, scientists, infrastructure providers and experts will lead to the wider endorsement, collection of further inputs, the refinement of the first strategies of the Green Paper as well as a prioritization of topics. It will help to compile success criteria for Citizen Science in Europe, best practices, as well as potential risks and requisites for the broader implementation of this approach.

This consultation process will be organised from 7th of January to 7th of April 2014 in the on- and offline world.

Open consultation process

The Green Paper will be published and put under discussion by the stakeholders using a collective consultation tool, supported by social media. This tool will support the open debate, facilitate the collection of the stakeholder's knowledge, provide an overview of the topics under discussion, identify further experiences from the field, open questions and policy recommendations. Follow-up roadmap and implementation of the outcome of the White Paper will be also taken into account.

Endorsement and debate workshop

After the deadline for submitting responses, the SOCIENTIZE project will organise a workshop to present and discuss the outcome of the consultation. The Green Paper will be presented in workshops, science events and conferences amongst the stakeholders.

The feedback from the open consultation process and the workshops will be collected analysed, synthesised and feed the White Paper on Citizen Science.

Invitation to the consultation process

Consultation will be disseminated between main stakeholders and the general public. All participants, who have already contributed to the Green Paper, will be actively involved in the online and offline consultation activities. In addition the dissemination channels of the SOCIENTIZE consortium (company and personal networks, social media, newsletters and websites etc.) will be used to broadly distribute the invitation to participate in the consultation process throughout this three months period. Stakeholders for the consultation are scientists, science communicators, Citizen Science experts, Citizen Science volunteers, artist, policy makers, organisations, and infrastructure providers. European and national policy officers are invited to promote the debate with their stakeholders.

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2. STATE-OF-THE ART Analysis

This chapter is structured around the main topics that evolved from literature analysis and expert interviews. It always contains three chapters per topics:

- State-of-the Art from Literature
- Expert interviews
- Discussion

2.1. Definitions & Models of Citizen Science:

2.1.1 State-of-the-Art from Literature

As soon as one starts to investigate the field of citizen science it becomes clear that this term comprises manifold activities and approaches that somehow link the public with scientific research. General definitions for citizen science understand it as "a partnership between volunteers and scientists to answer real-world questions," (Rick Bonney, director of program development for Cornell University's Laboratory of Ornithology in Ithaca, New York, in (Cohn, 2008: p. 193)) or "Citizen science engages non-professionals in authentic scientific research" (p.291) (Dickinson et al., 2012: p. 291)

At the one end of the spectrum, the definition encompasses activities that involve citizens as rather passive contributors to scientific research. Citizen science projects are defined by some as "partnerships initiated by scientists that involve non-scientists in data collection." (Bonney, Cooper, et al., 2009) or as "field assistants in scientific studies" (Cohn, 2008: p.193). At the other end, it comprises approaches that suggest that researchers immerse themselves into local communities, to closely collaborate with local actors and citizens, identify research questions and provide their scientific skills in order to solve relevant issues of todays' society (Mueller, Tippins, & Bryan, 2012).

Originally, citizen science evolved as an approach where citizens supported scientists with data collection. The term "Citizen Science", which emerged during the 1980s, has traditionally been used when some aspect of the data collection or analysis was beyond the capacity of the core science team and thus a distributed network of volunteers supported the research team. In this context citizen science – although not labelled under that term then - has been practiced since at least the 18th century, starting in the fields of astronomy and ornithology (Raddick et al., 2009).

But this initial scope of activities and understanding of citizen science has been changing considerably over the last years. Due to the development of sophisticated Internet applications which effectively utilize crowdsourcing for data collection over large geographic regions, citizens science experiences considerable expansion (Dickinson, Zuckerberg, & Bonter, 2010) What changes nowadays is the "number of studies that use citizen scientists, the number of volunteers enlisted in the studies, and the scope of data they are asked to collect", says Jennifer Shirk, a graduate assistant and project leader at Cornell's Laboratory of Ornithology (Cohn, 2008: p. 193). At the same time, advances in data storage and web technology are making the increasing amount of collected data, including images and audio(-visual) files, easier for volunteers to access. Social networking technologies such as forums and blogs are allowing communities to form around a shared interest in scientific research (Raddick et al., 2009).

But not only technology changes the scale and scope of citizen science. A growing number of researchers criticise the dominating model of volunteers as mere “data drones” and demand a more engaging role for citizens. (Hemment, Ellis, & Wynne, 2011, p. 63). In the traditional top-down projects a true collaboration between scientists and participants is often missing. Thus, Mueller et al. (2012) define citizen science much broader: **“**Citizen science is incisively conceptualized as community-centered science, community science, participatory community-action research, street science, traditional ecological knowledge, social justice, scientific literacy, and humanistic science education.” (ibid, p. 12) It is an approach, which helps to democratise science education, fostering students’ understanding how science can be relevant to their lives and communities. Their vision is that communities become “minilaboratory for democratic participation and citizen science as a tool for e.g. conversation in a neighourhood can help to culminate divers actions of inquiry.”

Due to these different understandings and activities subsumed under the term “citizen science”, first attempts were undertaken to identify typologies of citizens science projects by some experts in the field.

(Shirk et al., 2012) propose the new term of “public participation in scientific research” (PPSR) to cover the different contexts and traditions of public participation in scientific research. They define “PPSR as intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge” (ibid, p. 29) and cluster PPSR projects according to (1) the degree of public participation in the research process and (2) the quality of public participation as negotiated during project design, and state that both aspects considerably influence the projects’ outputs.

Concerning the degree of public participation they come up with five project models (ibid, p. 4):

- **Contractual projects**, where communities ask professional researchers to conduct a specific scientific investigation and report on the results;
- **Contributory projects**, which are generally designed by scientists and for which members of the public primarily contribute data;
- **Collaborative projects**, which are generally designed by scientists and for which members of the public contribute data but also help to refine project design, analyze data, and/or disseminate findings;
- **Co-Created projects**, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process; and
- **Collegial contributions**, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals.

At one end of the spectrum, in the contractual model, the public participates by raising a question; they are consumers of scientific knowledge produced by scientists, with enhanced control over the research agenda and the resulting knowledge produced. At the other end of the spectrum we find the collegial model, where amateurs adopt the traditional role of "scientists-as-knowledge-producer" and bring in their expertise to contribute to questions "that may not otherwise transpire owing to a lack of resources, time, skills, or inclinations in the professional scientific community". In the middle of the spectrum, contributory projects serve to deliver reliable scientific research outcomes and increased content knowledge, whereas co- created projects proved to be successful in influencing policy decisions and improve the resource management and stewardship of communities.

(Wiggins & Crowston, 2011) elaborated another typology of citizen science projects. In their typology they do not only focus on types of scientific tasks performed by volunteers or the degree of involvement, but also consider organizational characteristics, enabling technologies, and goals of projects. Based on the clustering of existing projects, the authors identified five types of citizen science projects, which they labelled Action, Conservation, Investigation, Virtual and Education (ibid, p. 5-8):

Action: Action oriented projects use bottom-up and grass root initiatives to encourage participant intervention in local concerns, using scientific research as a tool to support civic agendas. Professional researchers are most likely engaged as consultants or collaborators rather than initiators. The collected research findings serve mainly to provide evidence for intervention and not as further contribution to a scientific knowledge base. Typically these projects take place at a local level and do not scale well without substantial organizational development. The primary challenge of these projects is sustainability, showing substantial efforts in looking for donations, sponsorship, membership or other fundraising initiatives. Technology-wise these projects use only lightweight technologies and rely more heavily on co-presence at meetings and events to communicate.

Conservation: Conservation projects engage citizens mostly in data collection activities and aim to "support stewardship and natural re-source management goals, primarily in the area of ecology" (p.5). They are strongly linked to a place and have some explicit educational goals.

The generated data mainly serve to support management decision-making of e.g. political stakeholders, and to promote volunteer' stewardship and awareness. While the focus is on management issues, careful attention is paid to scientific valuable data. Conservation projects have either top-down (researcher-initiated) or middle-out (management-initiated) form of organization, are mostly long-term monitoring activities and depend heavily on federal or state funds. Technology use is either fairly limited or fairly sophisticated.

Investigation: Investigation projects require the collection of data from the physical world for scientific goals. These projects often acquire a large scale of participation, from regional to international scope, and while education is not an explicit goal it is frequently a strongly valued purpose. These projects are mostly initiated by academics, carefully designing the project and tasks, as the scientific validity of data is the main concern. These projects employ a variety of validation methods (e.g., uniform equipment, entry form validation, triangulation, algorithmic flagging for expert review). Investigation projects are normally organized top-down by academics or non-profit conservation organizations. The large number of volunteers quickly leads to sustainability and management challenges and often these types of organizations engage in some kind of fundraising. Technology-wise these projects employ a wide range of technologies, taking advantage of the efficiency offered by web-based data entry, but rarely providing data in readily usable format.

Virtual: Virtual projects share the same goals as investigation projects, but all activities are ICT-mediated with no physical elements whatsoever. Like investigation projects, virtual projects aim at the creation of valid scientific results, but valuable data is collected only via online participation and require a critical mass of volunteers. To keep volunteers' motivation high these projects take advantage of natural human competitiveness, creating engaging game-like task designs, and sometimes the potential for discovery of a proverbial needle-in-a-haystack. These projects are organized top-down by academics and rely on research funding. Technology-wise these projects often make use of complex web platforms.

Education: Education projects have education and outreach as primary goal, providing formal or informal learning opportunities in collaboration with researchers. The emphasis tends to be on outreach, learning, and developing scientific inquiry skills, rather than on generating scientifically valid results. Students are for instance supervised to form and test their own hypothesis, using data compiled from their own work as well as other classrooms' contributions. These projects are considered citizen science only by virtue of including a research partner as an organizer. They are organized top-down and involve multiple types of partner organisations.. Technology-wise all education projects used technology to support data entry, with some making fairly sophisticated use of technology.

Both classification schemes presented above do not include explicitly what is commonly labelled as "volunteer computing" in their definitions of citizen science. (Wiggins & Crowston, 2011) argue that in their understanding providing computing resources for projects like SETI@home or participating as a subject in a research study is not part of citizen science as volunteers are involved only passively in scientific work and this passive involvement differentiates these approaches from citizen science. However a large share of projects that are currently labelled under the term "citizen science" are volunteer computing projects.

Finally, there is an emerging new trend in citizen science, namely involving citizens in the decision making process about the research lines publically financed to scientists. In France, e.g. the Centre National de la Récherche Scientifique, CNRS, started an initiative to promote the dialogue and reconciliation between research and citizens in cancer research and to introduce a citizen committee involved in decisions of methodology, protocols, etc. Such an approach might be valuable in certain cases, but also includes its risks and has not received general acceptance yet amongst the scientific communities.

2.1.2 Expert interviews

The expert interviews stress the wider concept and broad scope of citizen science. It is understood as scientific investigations done by amateurs or not being done professionally (Exp2), so anything that is not professionally accredited science is citizen science (Exp6).

Experts agree that citizen science should not be limited to a narrow definition and can have different levels of involvement. It can range from citizen science understood as a methodology to involve citizens in issues about poverty and governance as well as it can involve those projects, which use citizens as source of data collection (Exp1). The main aim is to advance scientific understanding but not necessarily do scientific work. Thus the scientific work is in its heart and this is true for all project types.

In this broad understanding, volunteer computing is also part of citizen science, although on the lowest level of involvement (Exp2, Exp5, Exp6, Exp7). The term “cyberscience” was mentioned, as a mash-up of activities supporting scientific research and done on the Internet, putting the focus on the Internet and what it adds to citizen science (Exp6). The different levels of involvement can help scientists to involve volunteers in many ways as it best fits the project. Scientists can provide volunteers a scaffold leading them to an increasing engagement, starting with easy, quickly tasks like volunteer computing and getting more deeply involved step by step (Exp2).

One interviewee stresses the important aspects of equality between scientist and citizens. In his understanding it is critical that citizens are involved in the co-design of the research project and they are seen as an equal partner in the methodological development (Expt4).

2.1.3 Discussion

In SOCIENTIZE we argue that all citizen science typologies or models have specific values and contributions to science and/or society and thus should be supported by political stakeholders. There are differences regarding the outcomes, benefits and also motivational issues for participation in these different types of citizen science projects, which will become apparent in the following chapters.

The wide portfolio of citizen science activities allows the involvement of different groups of citizens at different degrees and levels in scientific research. We also suggest understanding volunteer computing as part of citizen science, involving those citizens who are probably less willing to spend their time and cognitive resources, but are motivated by technology-affinity and the readiness to contribute with computational power to research projects – maybe as a first step of involvement.

As (Raddick et al., 2009) state it in their vision for the future of Citizen Science “many people would participate in Citizen Science at various levels of engagement. Some would participate by engaging in the central Citizen Science task. Some would participate by interacting with the volunteer social network through blogs, forums, or other social networking technologies of the future. Some would initiate projects and work with guidance from scientists to write and publish their own research papers.” Also (Shirk et al., 2012) suggest that projects can facilitate different degrees of participation by different individuals. They refer to (Lawrence 2006) who found out that it is likely that individual participants create their own unique experiences, regardless of a project’s predominant model of participation. In co-created projects, people can be differently involved as well, where the most active ones feel motivated to participate in all phases and activities of the project, while others are involved in smaller, well-defined tasks like the data collection and analysis (e.g., Bonney, Ballard, et al., 2009). Based on their lessons learned, first contributory projects like Galaxy Zoo, decided to provide volunteers with background information and the collected data in order to allow those who have specific skills and interests to initiate their own research projects and contribute more deeply to science then others (Fortson et al., 2011).

The possibility of involving different volunteer groups at different stages of the research process and to a different degree should ideally be considered at a project design stage. As (Nov, Arazy, & Anderson, 2011) say “It requires dynamic contribution environments that allow volunteers to start contributing at lower-level granularity tasks, and gradually progress to more demanding tasks and responsibilities.” The empowerment of the volunteers and corresponding governance structures should this be considered from the beginning of any citizen science project.

We also suggest putting further focus on investigations that try to find how the levels of involvement from citizen scientists can change over time and in the long run of the project, how volunteers change from one state of participation to another, what are time points for these changes and motivational drivers and/or barriers.

2.2. The role of technological innovations for citizen science

2.2.1. State-of-the-Art from Literature

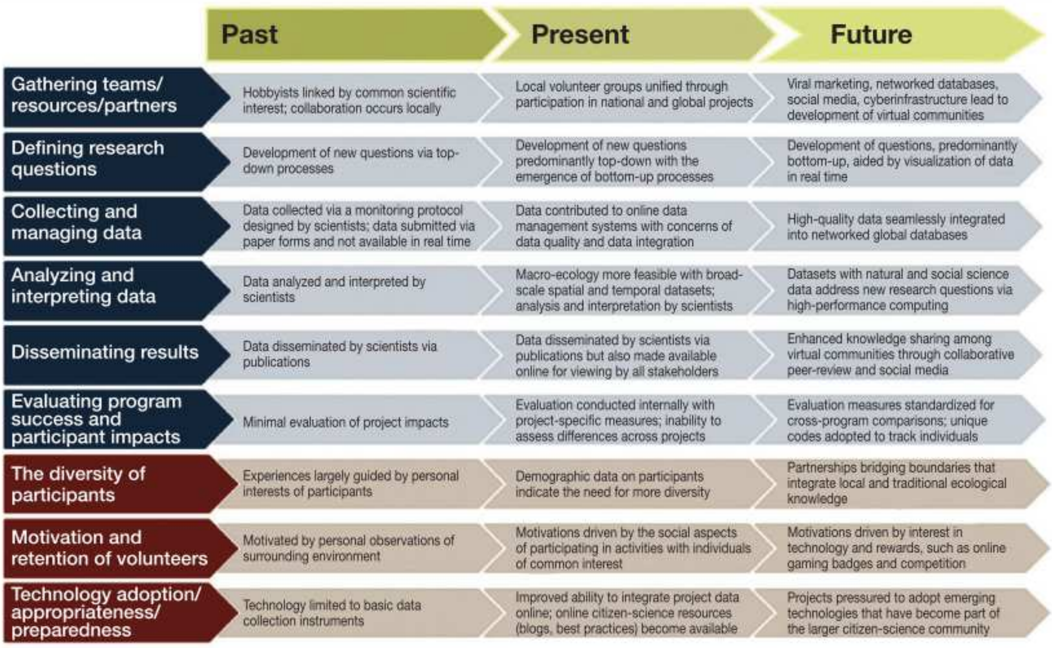
Technological innovations considerably influence the expansion and development of citizen science (Cohn, 2008; Dickinson et al., 2010; Fortson et al., 2011; Silvertown, 2009; Wiggins & Crowston, 2010) and thus need to be carefully considered in any future recommendation.

First, there are the increasing number of advanced web-based services and applications, as well as the underlying infrastructure to store huge data sets, which offer easy to use data entry forms, forums & blogs to foster discussion between volunteers and/or scientists, competitive motivational elements and more playful approaches to citizen science. The same web-based tools are also democratizing project development, allowing for the creation of data-entry systems for community-based projects that arise out of local, practical issues or needs. (Dickinson et al., 2010)

Second, there is the increasing number of ubiquitous devices, which facilitate the data collection and contribution to citizen science when being out and about. (Paulos, Honicky, & Hooker, 2008) stress that “We need to expand our perceptions of our mobile phone as simply a communication tool and celebrate them in their new role as personal measurement instruments capable of sensing our natural environment and empowering collective action through everyday grassroots citizen science across blocks, neighbourhoods, cities, and nations.” GIS (geographic information system)- enabled web applications allow participants to collect large volumes of location-based data and submit them electronically to centralized databases (Dickinson et al., 2010). Locative technologies in combination with global information sharing, creates an unprecedented capacity for participatory mass observation on for instance the environment and climate. (Hemment et al., 2011). Wireless sensor networks, which consist of spatially distributed, autonomous or semi-autonomous sensors that monitor physical and/or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollutants could enrich the (automated) collection of data of volunteers (Newman, Graham, Crall, & Laituri, 2011).

(Wiggins & Crowston, 2010) analyse the technology use for each of the citizen science project typologies they developed (see above), while (Newman et al., 2011) investigate the use of technology in the different research phases:

- In the initial phase of **gathering teams/resources/partners** existing databases can help individuals to find projects, resources and partners. In addition social media will facilitate participants' connections.
- When **defining research questions**, modern collaboration tools can link scientists with volunteers and foster creative discussions of research questions through a real-time dialogue. The meta-analysis of data across different projects will support the top-down and bottom up definition of project goals and scientific discovery.
- When **collecting and managing data sets**, mobile phones can be transformed to "networked mobile personal measurement instruments" (Paulos, Foth, et al., 2008). Location based applications can automatically capture participant's locations or provide location based alerts. In general ubiquitous, networked devices and data collection forms on the Internet will facilitate the process of data collection, which inevitably requires improved data and privacy management capabilities to deal with the increasing volume of data.
- When **analyzing and interpreting data**, new challenges posed by analyzing large- scale data will be addressed by innovation in statistical analysis and modelling. Grid and cloud computing will expand analytic capabilities and improved browser-based visualization and analysis tools will allow providing the collected data to participants more easily.
- For the **dissemination of results** innovative collaboration tools will facilitate the collaboration and dissemination of results across projects, centrally consolidating scientific information across projects, promoting collaborative writing, and create virtual forums and communities (Hoffmann 2008; Waldrop 2008)
- During the **evaluation of program success** and participant impacts, the vision is that standardized and electronically available impact measures will enable comparisons across diverse projects. In additions new technologies will allow to track individuals participating in different research projects and over a longer period of time, thus helping to understand patterns of contribution.



	Past	Present	Future
Gathering teams/ resources/partners	Hobbyists linked by common scientific interest; collaboration occurs locally	Local volunteer groups unified through participation in national and global projects	Viral marketing, networked databases, social media, cyberinfrastructure lead to development of virtual communities
Defining research questions	Development of new questions via top-down processes	Development of new questions predominantly top-down with the emergence of bottom-up processes	Development of questions, predominantly bottom-up, aided by visualization of data in real time
Collecting and managing data	Data collected via a monitoring protocol designed by scientists; data submitted via paper forms and not available in real time	Data contributed to online data management systems with concerns of data quality and data integration	High-quality data seamlessly integrated into networked global databases
Analyzing and interpreting data	Data analyzed and interpreted by scientists	Macro-ecology more feasible with broad-scale spatial and temporal datasets; analysis and interpretation by scientists	Datasets with natural and social science data address new research questions via high-performance computing
Disseminating results	Data disseminated by scientists via publications	Data disseminated by scientists via publications but also made available online for viewing by all stakeholders	Enhanced knowledge sharing among virtual communities through collaborative peer-review and social media
Evaluating program success and participant impacts	Minimal evaluation of project impacts	Evaluation conducted internally with project-specific measures; inability to assess differences across projects	Evaluation measures standardized for cross-program comparisons; unique codes adopted to track individuals
The diversity of participants	Experiences largely guided by personal interests of participants	Demographic data on participants indicate the need for more diversity	Partnerships bridging boundaries that integrate local and traditional ecological knowledge
Motivation and retention of volunteers	Motivated by personal observations of surrounding environment	Motivations driven by the social aspects of participating in activities with individuals of common interest	Motivations driven by interest in technology and rewards, such as online gaming badges and competition
Technology adoption/ appropriateness/ preparedness	Technology limited to basic data collection instruments	Improved ability to integrate project data online; online citizen-science resources (blogs, best practices) become available	Projects pressured to adopt emerging technologies that have become part of the larger citizen-science community

Technology use in different research phases (from Newman et al., 2012: p. 303)

2.2.2. Expert Interviews

Experts highlight the important role of technology for the citizen science field. Technology-wise, the experts mentioned the following aspects:

Platform:
There is a need to better link individual citizen science projects, platforms and data sets via more standardised, international tools and interfaces to harvest from the opportunities from citizen science.

Open source:
Citizen science platforms and software should be free to use and preferably open source (Exp3, Exp7), as this would best fit the initial idea of voluntarity, openness and collaboration. However, open source platforms could also attract citizen science projects with a lower scientific value, as potential review processes are omitted. (Exp7). Openness is a clear issue for the future of citizen science.

Examples of open source software mentioned are the transcription tool developed for the "Old Weather " project, which can be downloaded from Github, or the volunteer computing platform BOINC.

Access and interoperability of data sets:
Another issue mentioned more specifically was the access and interoperability of the citizen science data sets. Even the large data sets based on citizen science data have been created by scientists for their own needs and are often difficult to be used by other groups, like citizens or researchers. There have been first efforts in the United States to synchronising data amongst data sets, but these efforts are still in the very early stages. That's why one of the big goals is that people working in this field define data standards that all citizen science projects can use (Exp2).

Public authorities should provide open access to their data too (Exp2, Exp4) to be used by citizen scientists for their research and also increase interoperability between these data sets.

Data storage:
Another technical challenge is the storage of big data. This requires features that allow distributing huge amounts of data. For volunteer computing dealing with huge data sets would require a lot of volunteers' disk space, but this disk space needs to be liberated when users want to use it.

Mobile devices:
Future citizen science applications have to run on mobile devices. Standardisation and interoperability of different apps developed from different projects is thus a concern. For volunteer computing the increasing importance of mobile devices also means a trend towards powerful processing power and CPUs, where computing tasks could be conducted when the device is for instance charging or not in use at night. Exp3 states that the trend towards mobile devices also affects the architectural choice. Stressing the importance of flexibility, he suggests working with virtual machines like it is done with BOINC (Exp5).

Challenges with the use of mobile devices arise from different operating systems, for instance the rules for iPhone apps are rather restrictive. Paying to add something to the Apple store is not congruent with the open source concept of many citizen science initiatives (Exp5).

2.2.3. Discussion

The state-of-the art analysis shows the important role of technology for citizen science. It provides completely new ways to address and involve volunteers in the collaborative collection, analysis and discussion of citizen science data. But with the increasing usage of advanced technologies in all phases of citizen science projects, there are also important challenges that need to be addressed and that we perceive as relevant for the White Paper on Citizen Science:

Management of huge data sets:

The overall data volume will lead to opportunities for data re-use and meta-analyses but may also present novel challenges related to "data deluge". (Newman et al., 2012) *It requires investments in the infrastructure to store, preserve and analyse huge data sets, but also the development of common metadata, standardization and interoperability between different projects and databases* (Rotman et al., 2012). *Interoperability and real-time synthesis is also required between citizen science and for instance environmental and social data* (e.g. databases containing information on land cover, topography, census data, - a task which can be complex and computationally intensive.

Elaborated approaches to ensure the data quality will play an important role *and good data stewardship practices, as well as sociocultural changes such, as promoting informatics literacy, data sharing, and scientific transparency and reproducibility* (Michener & Jones, 2012) are required in the future. This means e.g. adopting increasingly rigorous protocols such as repeated sampling at predetermined intervals, improved strategies for reducing spatial biases, use of quizzes and games to evaluate observer skill, and tools for inclusion of data on observer quality in the database.

To work with large, distributed data sets it will require *research and training in new computational and statistical modelling approaches*, also including tools for exploration, analysis, and displaying results. The attention is not only on the collection and storage of data from citizens, but also on the *provision of these data to the public for further co-created or collegial contributions to science.*

Sustainability of data repositories is an important issue for funding agencies as most projects face the challenge of maintaining funding for cyber-infrastructure and databases (Dickinson et al., 2012).

Handling of sensors:

(Paulos, Foth, et al., 2008) argue that the handling and usage of the sensors and measurement conditions will vary wildly. Current questions related to the use of sensors are: how can these sensors be reliably calibrated 'in the wild'? How can we create a common citizen science knowledge pool, lingo and nomenclature to identify, share and discuss measurement data? What would be a reasonable set of sensors to use and what conditions make sense to measure?

Privacy issues:

If citizen science projects make more and more use of social media and web-based applications and services, that allow volunteers to easily switch between projects and provide sensible data like geographic location, disclosing daily location traces and patterns, privacy is a big concern. It *will need mechanisms that guarantee that the privacy of volunteers is assured and each individual has the flexibility to decide on his or her personal level of anonymity.* It requires finding new ways that allow a certain level of anonymity for users while on the other hand fostering discussion and open debate with their data.

Shared platforms for citizen science projects

(Rotman et al., 2012) suggest the creation of a common infrastructure for citizen science projects that is used by projects in various domains and would help to attract, connect and manage the various stakeholders involved.. (Raddick et al., 2009) recommend that developers create a standardized set of web-based software to allow volunteers to use a standard interface for many different Citizen Science projects, lowering barriers to entry into new projects. Thus old citizen science projects could bridge into new ones, with the same volunteer community and standard interfaces. The authors recommend also that designers of existing and new Citizen Science projects work closely together to establish and implement best practices in Citizen Science project design.(Paulos, Foth, et al., 2008) refers to open platforms and software for sharing which support citizen science and grassroots activism.

These suggestion has already been taken up and several platforms that provide access to volunteers and tools of citizen science projects are now available.

e-Inclusion:

Technology is not only an advantage, but may become a barrier. Its important to check how actual access to technology will affect the development of citizen science and how it can allow the participation of all members of society. One of the worst-case scenarios is that citizen science will become a rich people sport, creating a huge barrier between technologized and non-technologized citizens, between poor and rich societies or countries. Also in European countries the crisis might reduce the access to news technologies like smartphones or tablets with high-speed Internet connection, not only in private households, but also in schools and public institutions. Other groups within Europe that might be excluded from an increasing technologized citizen science movement are those groups touched by the digital divide, like older people, people in remote country sides, or citizens from lower social classes. So it has to be carefully investigated how those groups can be included in spite of the increasing use of technology in citizen science projects.

2.3. Motivation of volunteers and scientists

2.3.1. State-of-the-Art from Literature

Attracting and retaining people who would be willing to contribute their skills, time, and effort for a scientific cause is an important pillar of citizen science work and has received little attention so far (Nov & Anderson, 2011). There is a limited number of studies on motivational aspects in citizen science and most of them come from traditional contributory models (Shirk et al., 2012) or investigation projects (Wiggins & Crowston, 2011). The main outcomes from these articles are shortly presented in the following chapter:

(Raddick et al., 2010) came up with a list of 12 motivational categories for participation in Galaxy Zoo[1], a project that involves volunteers in classifying galaxies, stressing that most users do not have a single motivation. Amongst the most frequent motivations there were 1) the interest in astronomy, 2) the excitement to contribution to original scientific research and 2) being amazed by the vast scale of the universe.

(Fortson et al., 2011) describe that amongst the most motivated volunteers were those who initiated their own little research projects and defined research questions on their own based on the provided data. Having made this experience the Galaxy Zoo team realized how important it was to provide links to supporting information and analysis tools related to the objects shown in the primary task. This is to enable the user to conduct their own research and allows for users to learn the process of research aided by peer-mentoring. Some of the Galaxy Zoo volunteers wanted much more than just to classify objects. They built a community of the volunteers, by the volunteers and for the volunteers, where they exchanged individual observations, research questions etc.

In another study (Nov et al., 2011) defined six motivational drivers that influence the behavioural intention to increase participation in citizen science projects. The desire to advance the project's objectives is a characteristic that helps explain why people join the project in the first place. Therefore, especially among new volunteers, communicating the project's mission, achievements and its scientific contributions is of importance. However once active contributors, attributing importance to the project's objectives is not linked to intentions and contributions level any more. What proves to be important for both active and passive volunteers, is the high level of intrinsic motivation which correlates positively with the level of contribution and thus stressed the need to develop enjoyable contribution mechanisms, if volunteers want to be kept motivated. The importance of intrinsic motivations is an important argument for the design of more game-like approaches, like it is done for instance in Foldit[2]. (Nov & Anderson, 2011)

The authors stress that the necessity to establish a community of volunteers who share beliefs, interact regularly, and work collectively towards a common goal is of secondary importance but should not be neglected. Being in a team, or the possibility of it, strengthens the relationship between volunteers' identification and their participation intention. And finally the authors recommend to "create dynamic contribution environments that allow volunteers to start contributing at lower-level granularity tasks, and gradually progress to more demanding tasks

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1 http://www.galaxyzoo.org/

2 http://fold.it

and responsibilities" (Nov & Anderson, 2011)

(Dickinson et al., 2012) suggest that volunteer activities have to be "easy, fun, and social" to recruit a large number of volunteers. Opportunities for social interaction, enjoyment of the outdoors, and altruistic motivations are important in sustaining volunteer effort as well. On the other hand incentives, certificates of recognition, and challenges, are interesting extrinsic motivators.

Finally (Rotman et al., 2012) defined two pivotal points in volunteers' participation that are highly affected by motivational factors: the initial decision to participate in a project and the decision to continue this engagement once the initial task is completed. The authors argue that volunteers' motivations are temporal, dynamic and change even when the ultimate goal remains the same. They recommend adequate timing of motivational triggers, transparency in data usage, a local grounding of the research topic and the breaking up of large tasks into small building blocks in order to keep volunteers motivated.

But motivational issue do not only consider volunteers, they are also relevant for the involvement of scientists, only that this issue is less frequently investigated and discussed.

Involving non-scientists in a more and more collaborative manner to scientific research is something which tends to wary some of the scientists, educated, trained and placed within the hierarchical academic world (Rotman et al., 2012). Important issues for research collaborations are shared vocabulary, practices, meanings, but also competencies, mutual recognition, prestige. Thus bridging between scientists and volunteers and establishing trust-full, balanced collaboration between these groups is not always an easy matter.

The range of motivational drivers for scientists is more limited than amongst volunteers (Rotman et al., 2012). The main objective for collaborating with citizens is the opportunity to gather large-scale data and use these data in common peer-reviewed publication processes. There were single examples when volunteers were involved in a broader set of activities and seen as more equal partners, but these cases were the exception. Some researchers would welcome volunteers taking more complex roles, but don't think that these volunteers are so easily to find. A second motivation was the educational aspect, the objective of scientists to introduce citizens to their domain and to increase participants' understandings about scientific processes in general. Scientists expected that educating volunteers would foster their understanding about the role of science in society.

Motivational barriers from the scientists' side were worries about the citizens' commitment and the quality of volunteers' work. Trust and credibility on both sides are the most critical points for successful cooperation between scientists and citizens, which requires openly communicating each other's' expectations and motivations and also fulfilling those.

(Dickinson et al., 2012) state that for projects that require moderate numbers of volunteers and substantial, continuous commitment, the best approach for participation may be to work closely with specific target audiences and to match the project activities to what the target audience finds rewarding.

This approach is taken up by co-created projects where researchers and volunteers develop a shared understanding of project goals and are involved in co-design activities. Co-created projects would not only allow reflecting on volunteers' motivational drivers but also on motivational aspects relevant for the involved scientists. In these kind of co-created projects motivational aspects might then be rather comparable to those of participatory projects in general.

Participatory or co-design projects require a philosophy of empowerment, equity, trust and mutual learning, thus all stakeholders are involved in the design process as early as possible and throughout the whole project. Motivational issues are related to the expectation management of different stakeholders, creating visibility and shared ownership for outcomes, creating organisational cultures that facilitate the collaborative processes where goals are negotiated and the outcomes are not always clear.

2.3.2. Expert interviews

The analysis of the interviews came up with several internal and external motivators:

One of the most powerful **internal motivators** is the personal interest in the research topic itself. The curiosity about real data and what to discover next (Exp7), learning more about the projects which can also stimulate further activities (e.g. going to university) (Exp6), or the aesthetics of pictures (Exp7) were more detailed aspects mentioned by the interviewees.

If it's not relevant and does not offer any value it will be difficult to attract volunteers. Therefore the early involvement of potential volunteers in participative research is so important, as it helps to understand what are the motivational drivers and barriers in the different contexts the research is taking place (Exp1, Exp4).

As another internal motivator comes the satisfaction to contribute and being involved in science (Exp1, Exp6, Exp7). To benefit from this trigger it requires showing to people how their efforts in science help to improve their environment, can benefit the local area and/or is contributing to a greater answer where a community of people helps to develop a larger set of understanding (Exp2).

Amongst the **external motivators**, experts mentioned divers aspects concerning recognition, competition and other incentives.

Social links and recognition: Recognition is one of the external motivators, which has to be stressed more. In one experts opinion people are less participating for recognition in terms of appearing in a paper. Interesting are less formalised ways of recognition, like an e-mail to thank volunteers in producing the paper, something that people could share on Facebook, saying that they contributed to a specific research project (Expt7). But also increased visibility in the public can be a motivator (Exp2).

In addition continuous personal links between the scientists and the volunteers are perceived as important. Key team members need to answer questions, in forums, blogs and Google hangouts to communicate what is achieved with the data. This is especially important to retain people who are already active (Exp7).

But also personal links between peers, the community of like-minded people, contact with others and sharing the same interest is an important motivator (Exp2, Exp6).

Competition: Concerning the usage of more gamified approaches and competitive elements different viewpoints can be found amongst interviewees.

One expert reported about bad experiences with competitive elements, like leader boards, which resulted in unhealthy behaviour, competing top leaders, complaints about each other and bad quality of the data (Exp7). In this regard cheating can become a problem, where some projects give more credits than they should and some people try to cheat in earning credits (Exp3).

If a gaming element is not implemented in a thorough and well design way, it can lead to frustration and retention of users. One of the expert states that with gamified approaches:

1. too many people would not feel that they are involved in real science projects.

2. Citizen science projects are competing with real games and this is hard to achieve, as research projects cannot compete with the big gaming industry (Exp7).

Other experts mentioned the positive aspects of competitive elements (Exp2, Exp6, Exp3). They attract many volunteers who do not care too much about science but want to collect credit points and win a game (Exp6). People like to collect points although it is not real money they would get, but the desire to compete is big. The gaming aspect is also related to social aspects, as people like to form groups and compete amongst them. A good example for including playful and competitive elements in citizen science, which was cited by several experts, is Foldit.

Incentives: Also in terms of incentives different viewpoints and experiences could be identified in the expert interviews: Volunteers are said to be often happy to collect credits, which do not have a real monetary value but express their efforts and thus has value for them. Also giving away small incentives like T-Shirts or similar is perceived as motivating. Exp2 also reports about small monetary incentives from 5 to 10 dollars, which can motivate large groups of kids or adults to do small works, while Exp3 states that what citizen science should not do is generating money, so the voluntary and charity character is important.

But money incentives, for instance, were the only way on how to get migrants involved in one of the citizen science projects, as money was the one thing the volunteers really needed to survive and which was the only way for them to be able to participate (Exp1).

In volunteer computing the fact that volunteers feel they have a very fast computer and that they can compete in online communities is an important motivational aspect. Studies about the volunteer population confirm that over 90% of participants are male and the mean age is 40. The challenge is to figure out how to reach other groups such as women and teenagers.

Regarding **motivational barriers** several experts stressed the importance of the **initial phase** of involvement, when volunteers engage in the citizen science project for the first time. Potential concerns need to be overcome. For this initial phase several recommendations to trigger motivation came up in the interviews:

- **Attractive design:** Projects need to look better, more entertaining, more professional like in a Web2.0 manner (Expt7). In other words, “you need beautiful and sexy projects” to attract a broader public (Exp3).
- **Establishing a dialogue:** Scientists need to communicate in an understandable manner the aim of the project and what is going to happen with the results (Exp 5). A dialogue has ben established between scientists and volunteers (Exp3). Volunteers have to learn to trust in scientists and/or the used technical devices (e.g. like in volunteer computing) (Exp3)
- **Low entry barriers**: Initial entry tests or registration processes causes people to quite. The entry barriers need to be low, e.g. via in-line tutorials or help-buttons and pop-up windows. Encourage the registration by offering some “specials” for users who log in

(e.g. special tasks, special data) (Exp7)

- **Support for the community of peers:** Social networking features, like forums or blogs, should be provided to support the community of peers as they motivate and support each other. (Exp3).
- **Adapted tasks:** Transfer difficult tasks it into something less complicated (Expt7**.** It is critical to find the right balance between tasks easy enough for volunteers to be conducted and interesting enough to keep their attention.
- **Mass media coverage:** Mass media have a broad reach and can have high impact, but the message has to be clear and simple. Journalists could take a supporting role in translating outcomes from a scientific paper into a language, which is attractive and understandable by the general public (Exp2).
- **Approach established institutions:** museums, zoos, schools, which have established structures to communicate to their members could be used as multipliers (Exp2). The scope of these institutions should be broadened from traditional groups in citizen science, like schools, to new volunteer groups like retired people. Retired people have a lot of time on their hands, are very active, and are often looking for new hobbies and social contacts. Certainly they have a lot of barriers to get involved, but approaching organisations 50+ would help to address these barriers. Youth organisations, like scouts, or business organisations addressing entrepreneurs could likewise be trageted.

Additional motivational drivers for **keeping people engaged** are:

- **Continuous communication:** Volunteers need to be continually updated about the scientific process and progress and what is happening with the data. It is important for volunteers to feel that there is actual progress due to their contributions. The real and open contact to scientists is important in this phase, giving volunteers the feeling that their contributions are treated with respect, also to establish and keep trust between volunteers and scientists (Exp7).
- **Workload:** There are motivational barriers mentioned related to the tasks and workload for volunteers. One expert mentioned the experience that in some projects there was not enough work for the volunteers, so people wanted to contribute and collect credits and the scientists did not have enough work for them, which was perceived as frustrating. (Exp3)

The **motivational drivers for scientists** mentioned in the interviews were the *usefulness for publicity* and *practical benefits to research* (Exp6), as well as *complying with new funding schemes* which increasingly focuses on impact from research (Exp4).

Experts reflected on a lot **of barriers for scientists**, which depend very much on the institutional settings and their support for participative research (Exp1).In many institutions there is still a lot of resistance and scepticism amongst researchers (Exp3, Exp6, Exp7). They still consider citizen science as an outreach activity (Exp7). On the other hand scientific interest depends also on the domain. In areas, where scientific knowledge is very distant from the social domain, where citizen insights have less to offer, it is certainly more difficult to find potential cooperation scenarios between researchers and scientists. Scientists who understand that research can be undertaken in the lived context, in the field, and projects can be co-designed by users and scientists will be certainly more open to citizen science (Exp4).

Suggestions on how to involve scientists where:

- **Approach whole institutions:** addressing institutions and their science managers, who see citizen science as outreach activity but also as an alternative to save costs, instead of researchers individually (Exp6).

- **Provide guidelines, support and best practice examples:** guidelines on how to conduct citizen science projects are needed and already offered (e.g. The toolkit at the Citizen science Central website[3]) (Exp1). Other ways to motivate scientists are articles that demonstrate successful projects but also easy to use platforms (Exp3).
- **Grant easy access:** Scientists need an easy access to citizen science projects (Exp3, Exp6). Many scientists, especially the older ones or less computer literates are afraid of using volunteer computing (Exp3) or they do not want to change their project design to offer participation..

During the discussion of motivational drivers and barriers the experts mentioned also the following **open issues**:

IPR and openness of data: Copyrights and IPR regulations are an issue for citizen science projects, which needs more attention in future. Sharing or providing access to the collected data is an issue her. Not only are scientists sceptical. It becomes even more complex when companies are involved and fund part of the research. They might then demand exclusive property rights (Exp7, Exp2).

One way of handling the data access is currently to restrict access the first 3 months to the initiating scientists before sharing data openly. (Exp6). IBM World Community Grid e.g. has adopted a policy of making the results public after 6 months after completion (Exp3).

Generally, most projects lack a clear ownership policy and especially volunteers are hardly informed about the intellectual property rights of projects they have been involved in. For the data handling of third parties even less regulations exist up to date (Exp2). It requires a political decision on how to deal with the access to scientific data, to follow open or closed science needs (Exp6).

Training on how to use huge data sets: As already mentioned in the technical chapter above, scientists require support on the data side, on how to collect, validate and handle huge citizen science data set (Exp2, Exp7). Also the collaboration in trans-disciplinary teams with data scientists are important (Exp7).

In addition project managers and scientists at scientific institutes need training on how to set up and conduct citizen science projects (Exp2).

Cost of infrastructure: Citizen science often deals with big data and thus infrastructure is important, but the funding of this infrastructure is an issue (Exp7). In order for volunteer computing to become an alternative for a wider range of projects, barriers such as concerns of local IT departments, still have to be overcome (Exp5). Economical reasons (e.g. the costs to build and maintain a cluster) will probably force a change towards more innovative, cost-free approaches like volunteer computing (Exp5).

Use of Social networking platforms: Citizen science projects should intensify activities on social media, such as Facebook (Exp7, Exp3). Social networking is an important aspect in citizen science and entry-level barriers could be reduced via social media. Facebook e.g. gives visibility

3 http://www.birds.cornell.edu/citscitoolkit/toolkit/steps

to the projects and to the volunteers (Exp3). But until now the use of Facebook as promotion tool for citizen science projects has been modest (Exp3, Exp6). Finding new ways on how to exploit social networks for citizen science is an interesting and open issue (Expt7, Expt6, Exp3).

2.3.3. Discussion

The different studies on motivation of volunteers show the importance of intrinsic motives, which refers to “doing something because it is inherently interesting or enjoyable” (R. Ryan & Deci, 2000, p. 55). In humans, intrinsic motivation is a pervasive and important one as it’s a natural motivation to take interest in novelty, to actively assimilate, and to creatively apply our skills. Amongst the intrinsic motives of volunteers, the studies found the interest in the topic itself or the fun of getting involved in one of the experiments. To support these intrinsic motives authors suggest providing valuable descriptions about activities and values of the project, defining tasks and interaction tools that are enjoyable to use, applying more playful approaches to citizen science involvement. Also providing background information for those who show high interested in the content itself and giving the opportunity to develop one’s own research question supports intrinsic motives.

On the other hand there are extrinsic motivations where an activity is done in order to attain “some separable outcome” (R. Ryan & Deci, 2000, p. 55). Examples for extrinsic motivators of volunteers are the recognition in the group of important others, visibility for one’s efforts, incentives, awards etc. In this regard on open issue mentioned by (Dickinson et al., 2012) is that citizen-science participants are rarely included as authors of peer-reviewed publications unless their efforts go beyond following a protocol and submitting data.

If a large number of volunteers should be attracted to citizen science projects intrinsic and extrinsic motivational aspects need be taken into consideration by project designers. In addition (R. M. Ryan & Deci, 2000) identified three supportive conditions which stimulate individuals natural activity and curiosity, help to keep this intrinsic motivation high and also internalize external demands. It is the feeling of autonomy and competence provided to participants as well as the power of the social context. With regard to the social context the most important factor to be supported is relatedness, namely in the sense of a feeling of belonging and being connected with others. In addition individuals need the feeling of being enough competent and efficacious to do the required activities, as well as the feeling of having autonomy and freedom to decide when to do what. In this light supporting activities for perceived autonomy, competence and relatedness are important to investigate. *Some of them were already mentioned in the state-of-the art analysis like the use of social networks, the provision of trainings, the definition of tasks for different difficulty and engagement levels etc.*

(Raddick et al., 2009) *require further research on who participates in citizen science, and what motivates participants' involvement at various levels.* From state-of-the art analysis we also think that *further research on motivational drivers/barriers in different project types, and the connection to more structured, existing theories of motivation* would be of value to the field. Similarly the changing degree of motivation over time should be studied. More analysis would also help to bring new insights in how *far competitive elements and/or incentive systems* can positively influence those volunteers who lack intrinsic motivation.

2.4. Outcomes

2.4.1. State-of-the-Art from Literature

Citizen science projects generate manifold outcomes and (Shirk et al., 2012) provide a good overview of outcomes for science, individuals participants and socio-ecological systems. Amongst the outcomes for science the most important ones are advances in scientific understandings, enhanced techniques for collecting, analysing, managing and networking data, peer-reviewed publications and reports. Individual outcomes embrace skill-acquisition, increased content and scientific knowledge, relations to nature and other people (volunteers, scientists), a sense of ownership. Outcomes for socio-ecological systems are better relationships between communities and management agencies, improved resource management strategies, higher willingness to participate in policy-decisions.

For this green paper we do not aim at a comprehensive list of potential outcomes from the various types of citizen science projects but rather want to identify some critical areas. Hence we continue with a presentation of outcomes frequently cited in literature as a basis for the discussion on open issues. The outcomes are structure into three chapters, first it discusses scientific advances through citizen science involvement, then outcomes related to advances in individual participants and finally outcomes related to local communities.

Scientific advances through alternative data collection and analysis:

The involvement of citizens helps to collect data that could not be collected any other way easily. Important aspects concerning the collection and analysis of data are summarized in the following listing:

- It allows gathering large volume of field data on large geographic scales or long time spans (Cohn, 2008; Devictor, Whittaker, & Beltrame, 2010; Dickinson et al., 2012; Silvertown, 2009; Worthington et al., 2012). While some data can be obtained with satellite images and other remote-sensing technologies, others can be acquired only through the involvement of massive research teams like those assembled by citizen science. Examples are conservation projects, which involve volunteers in the collection of data from large geographic regions.
- Many eyes are an effective way to find rare organisms, track invasions, or find the "needle in the haystack" (Raddick et al., 2009)
- Citizen science provides a framework for studying natural systems together with social data and thus it can serve to get much deeper insights in aspects that are related to cultural or societal aspects. Seen in this light, conservation projects are not only there for counting animals but also helping to capture additional social influencing factors that might be relevant for the conservation of certain species and plants (Mueller et al., 2012). "In urban and suburban environments, citizen science can match ecological monitoring data with data on human attributes, including educational/health statistics and participants' residential practices such as pesticide and water use, energy consumption, pet ownership, and residential habitat management, to better understand the impacts of cultural and behavioural practices on ecological response variables.“ (Dickinson et al., 2010: p- 151) Or as (Hemment et al., 2011: p. 63) suggest: It "… is to find new ways of citizen science that allow us to be more inventive with

people and with technology in ways which seek to capitalize on rather than exclude the idiosyncratic and less tangible dimensions of environmental „monitoring".”

- Concerning the analysis of research data a distinction can be made between the different kinds of involvement of volunteers: There are volunteer and grid computing projects where volunteers supply computing power to science to help with the conduction of computationally intensive analysis tasks (e.g. BOINC[4] or Ibercivis[5]). Other volunteer project use additional resources like time, cognition and human perception from volunteers to support the analysis of data. Examples for these projects are manifold and range from Clickworkers, which involves volunteers in the identification of craters on the Mars; to more playful approaches like Foldit, where volunteers support the attempts to predict the structure of a protein taking advantage of human’s puzzle-solving intuitions; or Zooniverse, a platform which provides access to several citizen science projects and a range of data analysis tasks e.g. the classification of images and sound files or the digitalisation of content. Zooniverse is also said to be the largest in terms of registered volunteers world-wide as well as in number of peer-reviewed papers based on the data analyized by volunteers (Fortson et al., 2011).

Public awareness, knowledge increases and changes in attitudes and behaviour of citizens:

Projects that directly involve members of the public in scientific research seem particularly suitable for increasing participants’ awareness, content and scientific knowledge as well as some changes in attitudes towards science and in behaviour related to the topic under investigation.

(Jordan, Gray, Howe, Brooks, & Ehrenfeld, 2011) investigated the impact of a citizen science project on the volunteers’ knowledge about the topic under investigation (in this case invasive plants) the understanding about scientific processes and if it resulted in actual behaviour change.

The results from this investigation show that collecting science data increased the awareness of the issue under investigation and resulted in increased content knowledge, but it did not result in a better understanding of scientific processes. This clear gain in knowledge together with limited gains in understanding procedural aspects of science was also confirmed in (Brossard, Lewenstein, & Bonney, 2005). The involvement of volunteers resulted also in slight behavioural changes, which expressed itself mainly by talking about the topic under investigation to others. Deeper changes could not be observed.

Bonney and his colleagues (2009) analysed the impact of ten projects which involved the public in scientific research – five Contributory, three Collaborative and two-Co-created projects. Their investigation showed that all ten projects seem to “contribute to awareness, knowledge, and/or understanding of key scientific concepts related to the study at hand. This conceptual understanding ranges from purely scientific information to environmental issues and regulations.” (Bonney, Ballard, et al., 2009, p. 44). In general learning seems to be more solid when volunteers have the opportunity to explore their own questions and are more deeply involved in co-design activities from the very beginning of the project. The authors’ analysis shows that especially Collaborative and Co-created projects have considerable potentials to provide volunteers with knowledge of scientific processes. Even

4 http://boinc.berkeley.edu/

5 http://www.ibercivis.es/

participants in Contributory projects report increased science inquiry skills, though to a lower degree.

The authors suggest that Collaborative or Co-created projects generate the greatest impacts in terms of understanding science process, developing skills of scientific investigation, and changing participants' behaviours toward science and/or the environment. This results is also confirmed in (Mueller et al., 2012) where the authors refer to the fact that "if an individual asks questions that matter to one's self or the community, and designs and carries out investigations in order to resolve environmental concerns, they are more likely to learn everything they need to know in order to resolve bioregional issues".

However, helping participants learn the skills that take them beyond data collection and into study design, data analysis, and data interpretation is a difficult task which requires a significant degree of individualized attention (Bonney, Ballard, et al., 2009). Finally, all three types of projects increased the publics' engagement in a range of scientific activities and provide opportunities for people to develop interest and engagement by either trying something new or by expanding previously existing interests. The advantage of the different types of citizen science models is that it allows individuals with different levels of expertise and interest to engage in science.

Support of regional and local initiatives:

In action-oriented and conservation projects scientific knowledge supports local (bottom-up) initiatives to provide evidence for interventions, support management decision-making and promote volunteer' stewardship and awareness (Wiggins & Crowston, 2011) .
An increasing number of literature points out to the benefits of combining local, practical, knowledge ("know-how") from communities with the scientific, systematised, de-contextualised knowledge ("know-why") from scientists (Reed, 2008). Combining these knowledge types and different understandings, helps to empower local communities "to monitor and manage environmental change easily and accurately" and is a possibility to create "more relevant and effective environmental policy and practice". (ibid, p. 9) It helps to better understand complex and dynamic natural systems and processes and thus evaluate the appropriateness of potential solutions to environmental problems. The different backgrounds and abilities of the stakeholder involved, fosters new ways of logic and innovation (Dickinson et al., 2012).

(Mueller et al., 2012) stress the important role of teachers and pupils in this process. They report about a project where prospective teachers acted as citizen scientists and immersed themselves into a local community, providing their scientific knowledge to the solution of actual problems and acting as agents of democracy. "In the process they learn that the teaching and learning of science must move beyond the transmission of an isolated set of facts to acknowledge the diversity of experiences, voices, traditions, and histories of people." (ibid, p. 10).

The authors promote " youth activism through citizen science as a pedagogy in which teachers and their students gather information to make the most informed decisions about potential consequences and collaborate with others to increase the degrees of confidence surrounding these choices. " (ibid, p. 11)

2.4.2. Expert Interviews

A core benefit of citizen science projects is the support one gets for answering the research question. But then additional benefits arise, depending on the type of project, which reach from getting citizens understanding the scientific questions to social contacts and personal benefits like knowledge increase for volunteers. And these additional benefits are of importance for researchers as well (Exp1).

Contributions to scientific questions:
Citizen science can bring viewpoints and perspectives not otherwise available to science (Exp4), bringing in more creative minds, allowing people from one field to help others on interdisciplinary and cross-disciplinary issues (Exp2). They can help to conduct better research faster (Exp7) and grant access to additional resources like time, effort, computer power (Exp3).
Researchers face some criticism for seeing volunteers just as another cheap source of labour and/or computer power. However volunteers participate on their own decision and people show real pleasure in discovering new things. For this reason one expert avoids the term “crowdsourcing” and prefers “crowdcrafting” where citizens drive research projects and benefit from the support of scientists (Exp6).

Value comes also from engaging the broader public in important science issues and debate (Exp4). In citizen driven science, where scientists are not leaders but supporters, new views and genuine questions from citizens are taken up. This does not apply to all fields, but e.g. urban science can profit from citizen driven science projects. (Expt 6). In participatory research where community groups, companies, public bodies, agencies are equal partners in a knowledge exchange, unique, distinctive and important insights not otherwise available to science may arise. (Exp4)

Engagement of the general public in science, knowledge transfer and knowledge exchange:

Public engagement, knowledge transfer and knowledge exchange are three distinct benefits (Exp 4). Citizen science is a good way to disseminate research to the general public in a gratifying way. Everyone can actively get involved, taking science out of its ivory tower (Exp1, Exp6, Exp7)

Depending on the types of citizen science projects, it can then be distinguished between knowledge transfer and knowledge exchange, while the former results in increasing volunteers’ knowledge on scientific processes in general and the topic of research more specifically; the latter contributes to a knowledge exchange between all involved stakeholders.

Through their participation citizens learn about the whole scientific process (Exp3, Exp6, Exp7) and it is perceived as important and useful for people to know how research is done, how decisions are reached, how the world works, and also have a better appreciation of it. (Exp7). However, only a fraction of people really learns something about the scientific process but the majority of people participate at low level without understanding the processes behind (Expt7). Citizen science also supports learning of the science topic itself partly with people of similar interests (Exp1, Exp6). Citizen science project could also foster creativity (Exp7).

It is more natural to engage citizens at a deeper level in issues that are about social topics. One example is the Future Everything festival where a lot of work is done with open data and open data infrastructure. Citizens are involved in designing new applications using these open data and gain important insights (Exp 4).

Community support:
Citizen-driven projects support local initiatives that are initiated by citizens, activists, where some have a scientific background but others not, for specific reasons. An example for this type of outcome is the "Public laboratories for open technology and science" and the activist actions in the BP oil spill (Exp6).

Community-driven science might be especially relevant in developing countries as well. Missing access to infrastructures often hinders people to act as scientists. Citizen science could be an opportunity to involve people in science at an early level and make large contributions for their own country, for themselves and for science in general (Exp2).

2.4.3. Discussion

As discussed above there are manifold outcomes from citizen science, also depending on the pe of project. From the above mentioned statements from literature and interviews there are some open issues that we can bring forward in our green paper.

Increase understanding of natural systems based on data about society

Citizen science provides new opportunities to widen the scope of traditional projects, combining natural systems together with social data. It has the potential to better investigate and understand how society and culture influences environmental issues and how these systems are dynamically interlinked with each other. The challenge is here to disconnect from traditional ways of conducting science and thinking about new opportunities for innovation and insights that lies at the interface of science and society and in the links between disciplines.

Support learning amongst volunteers based on more collaborative and co-created projects

Studies which investigated the knowledge increase amongst volunteers stress the importance of collaborative and co-created projects as well as projects which cover a broader spectrum of activities for volunteers to make learning amongst citizens more robust. This trend towards more equality between the involved stakeholders is and important aspects but when fostering collaborative projects there are some aspects to consider:

- Scientists tend to approach a specific scientific problem too narrowly instead of reflecting what additional insights the engagement of citizens can bring and how to engage them more widely.
- Feedback Loops – What types of feedback loops provide information that allows users to see how their behavioral change is impacting on the environment? (Paulos, Foth, et al., 2008)
- Be aware of "power dynamics that exclude individuals' participation" and that limit the levels of participation. Guidance of adults may become biased and compromise pepole's agendas. "Power dynamics will affect citizen science projects at any level (top- down or bottom- up), but less when community driven. " (Mueller et al., 2012)

- It is important to recognize volunteers as research collaborators, identifying them collectively, and name them. When Citizen Science projects recognize volunteers they provide an incentive for increased engagement and give volunteers ownership of the results. (Raddick et al., 2009)
- Consider and investigate potential tensions between interests and design requires in project design. Although certain degrees of participation may efficiently achieve particular outcomes (e.g., contributory projects generally result in large-scale data sets), projects should consider both whether a given degree of participation is sufficient to achieve desired outcomes, and if it is within the capacity of all partners to participate or facilitate. (Shirk et al., 2012)
- Investigate which tasks are applicable by volunteers and what kind of support (training, material, feedback etc.) would it need to facilitate participants' involvement.

Elaborate instruments and scales for impact measurement

Foster the elaboration and use of measurement tools and assessment scales that help to evaluate and compare the outcomes and effectiveness across multiple citizen science projects (Brossard et al., 2005). Assess what volunteers learn about science content and processes, and how participants' attitudes toward science change (Raddick et al., 2009). Develop resources based on these learning assessments.

2.5. Citizen science and artists

Artists may play a stronger role in citizen science. They can connect to the emotions of people, attract their interest and attention and creating some kind of action (e.g. taking a position). It is an interesting aspect to explore further for citizen science (Exp2).

In natural science there is an established area of sci-arts, where artists who often possess a fundamental understanding of scientific methods and problems, develop artworks. The objective of this artwork is not only to translate scientific results, but also to pose questions, enable scientists to look at problems in different ways and generate good art. The outcome may be art and science at the same time. An examples is "Climate Bubbles"[6]. Further projects are listed under http://futureeverything.org/ongoing-projects/.

The FutureEverything festival, which adapted the living lab methodology to an approach called "festival art lab", is another example of collaboration between researchers, citizens (amongst those developers and coders), musicians, artists and urban designers. The festival is conceived as a space, in which technology and prototypes can be co-designed, tested, alternated and becomes a space for social science in arts and humanity research (Exp4).

In SOCIENTIZE we have defined artists as one of the stakeholder groups we aim to involve in citizen science projects to analyse and benefit from the potentials that come from these cooperation for all involved stakeholder groups.

6 http://www.futuresonic.com/09/bubbles

2.6. Citizen science and schools

Educational aspects are often mentioned as an important motivator for citizen science projects as well as an explicit or implicit goal and a valuable outcome. While in the majority of projects the informal learning aspect of adult citizens is addressed, schools are more and more considered an important target for the introduction and promotion of citizen science. Critical and constructive participation in science from an early age on is regarded as a valuable step towards more democratic and informed citizenship (Mueller et al., 2012). In the context of SOCIENTIZE we have also defined schools as one of the main target groups and are currently exploring ways of integrating them in the most appropriate manner.

In the classification scheme of (Wiggins & Crowston, 2011) citizen science projects with a specific educational purpose tend to be top-down organised, are integrated in formal education and have only limited sustainability. Citizen science in schools is still in its infancy and literature base documenting experiences from practice is still poor. Publications on this topic stem mainly from the US and UK.

Experts have identified that there is a great potential to exploit, especially with regards to a critical approach in science teaching and "participatory democracy, where citizens actively collaborate in relation to accounting for future generations" (Mueller, Tippins, Bryan 2012). The examples from practice show however that there is still some important effort to be made in order to implement citizen science in school on a larger scale.

One of the most important aspects under criticism from a formal educational perspective seems to be the limited teacher - scientist - student partnership. The current trend in citizen science projects is top-down. However, teachers (and students) want to be involved in the design phase of the project, from the very start. The establishment of such partnerships on equal terms are time consuming and require direct interaction between scientists, teacher and students (Gray, Nicosia, & Jordan, 2012). Establishing and maintaining these partnerships is time consuming, as it requires personal interaction. However, it might help to clarify different expectations from the very beginning and tackle the current unequal power distribution: the real and perceived hierarchies among scientists, scientific knowledge, teachers, and students that are built into the structure of formal science classrooms present major challenges (ibid). Co-designing the project with teachers is important in order to integrate the project later into their lessons and it covers subject matters of a specific curriculum (Bonney et al. 2009).

Co-constructing science in the classroom requires a lot of effort and resources, it involves contributions from many actors and uncertainty about the process and its outcomes. Wide enactment will require significant support and commitment from a large learning community, and citizen science architects, scientists, teachers, and students will need to develop norms and structures for these collaborations that are often counter to the currently dominant expectations of the K–12 classroom and many citizen science projects (Gray et al., 2012).

Experts gathered by the British Science Association discussed recently the implementation of citizen science point of view from a pedagogical perspective. One question at the core of the discussion was about what needs to be done to get teachers motivated? According to Jeremy Airey from the National Science Learning Centre it is important to allow room for teachers to be creative, to recognise teacher's commitment to and involvement in Citizen Science for learners and to offer support for those teachers who need help in understanding Citizen Science and crowdsourcing. The documentation of case studies of citizen science projects in class to convince others has also been stressed by experts (Mathieson, 2013).

A recently held meeting of experts held by the British Science Association lists a whole range of important measures to be taken in order to support citizen science in school. Amongst this list of action items are e.g. the recognition and reward for researchers who lead citizen science projects with schools, a better understanding of the motivations, benefits and challenges of undertaking citizen science projects in schools, an overview of citizen science project offers and how they fit into the curriculum and a way to measure and communicate the impacts of citizen science projects (British Science Association, 2013) .

The importance of designing effective learning resources and working with educations to align goals has also been stressed from a scientific perspective. Scientists should promote inquiry and place-based learning objectives within their research methods. Scientists must work with educators to align their goals in collaboration. Despite traditional attitudes and understandings, there is an enormous potential for citizen science in formal education (Collins, 2013).

Exp2 stressed another open issue for the cooperation with schools. He mentions that many teachers involve pupils in scattered citizen science activities, for instance in conversation activities when it fits to the curriculum, but then pupils pass on to something else and never get in touch with citizen science again. What misses are long-term programs on how to engage pupils not only in individual projects for a limited period of time, but let them experience the whole potential of citizen science. He reports from a project where the authorities of school elaborated a concept on how different age-groups of students could get involved in one citizen science project, where the younger ones conduct tasks adapted to their level of knowledge and skills which are different from higher classes. This approach allows pupils to get more and more involved in citizen science activities with increasing skill level, but also requires a more thorough conceptualisation of these activities and a person in school dedicated to the elaboration and conduction of this program.

2.7. Data reliability

2.7.1. State-of-the-Art from Literature

(Alabri & Hunter, 2010) discuss the quality and trust of citizen science data. Based on a case study conducted in the CoralWatch project, they find that error in such citizen science data can be due to a diversity of factors that include: lack of validation and consistency checking; lack of automated metadata/data extraction; lack of quality assessment measures; and lack of feedback to volunteers on their data. The list of factors reported by Alabri and Hunter have been addressed by a number of strategies both in volunteer computing and crowdsourcing.

(Sarmenta 2002) addresses the problem of unreliable data in volunteer computing systems. In these systems, unreliable data is usually provided by saboteur volunteers, who submit bad results for the work they are given. Sarmenta proposes a credibility-based sabotage tolerance mechanism which identifies reliable data given a required level of credibility. The strategy estimates the conditional probability of data and workers being correct, based on the results of redundant task execution. These probabilities are used to estimate data credibility and direct the use of further redundancy.

In crowdsourcing, some strategies have been proposed to reduce error chance. For example, in stardust@home, before executing tasks, volunteers must go through a web-based training session and must pass a qualification test. This approach helps the project to avoid that unqualified volunteers execute tasks, while at the same time it trains volunteers to perform tasks. Another strategy is to provide feedback to volunteers on how well they have been performing. (Silvertown, 2010) argues that volunteers must receive suitable feedback as a reward for their participation. (Dow et al. 2012) show that in crowdsourcing feedback and assessment usually increase the quality of work performed.

Strategies to achieve data reliability in contributory citizen science projects are usually based on redundancy. However, defining the appropriate level of redundancy to achieve desired data reliability is a challenging task because they introduce a trade-off between redundancy degree and reliability guarantee. Maintaining a low level of redundancy may not guarantee data reliability and maintaining a high level of redundancy can lead to a high volunteer effort or computer processing power to obtain the reliable data. This trade-off is still little explored in the literature.

(Lintott et al. 2008) report that in the first release of Galaxy Zoo each task was executed on average 38 times to obtain the desired data reliability. The reliable data is extracted from this set of redundant data. A simple strategy to perform this extraction is to use majority voting, in which the reliable data is that most frequent in the set. However, majority voting does not perform properly when the error chance is high. To address these cases, (Edwin et al. 2012) proposes a dynamic Bayesian combination of data provided by multiple volunteers. The strategy applies

Bayesian combination to identify the uncertain of volunteers data based on data they provided in the past and on data provided by other volunteers which usually provide similar data. When evaluated on the Galaxy Zoo dataset, this strategy outperforms strategies based mainly on majority voting.

2.8. Additional open issues

Sustainability and funding:
Citizen-science projects face issues of prioritization and sustainability, raising the question of how government funding and partnerships might help sustain public interest in doing science for society. The primary challenges for most projects include maintaining funding for cyberinfrastructure, databases, and project leadership. (Dickinson et al., 2012)

Concerning funding there are different issues mentioned in the expert interviews as well as in literature: In general the long-time sustainability and the funding of citizen science projects is seen as a challenge for all types of citizen science projects. Potential approaches to address this challenge are:

Crowdfunding citizen science projects might be a solution. One expert argued that the problem with is approach is that this might lead to people having “a say” in what should come next in terms of research and which projects should be funded which then might intervene too much in the scientific process. The challenge here is to find the balance between openness and involvement on the one hand and keeping the original idea of the specific research project on the other hand (Exp7).

There are suggestions to add advertisements on the top of the page, but there is a worry that it would devaluate the project (Exp7)

Citizen Science Organisation:
(Newman et al., 2012) What is required from the authors point of view is a “dedicated professional association that disseminates, advances in the field through annual meetings,

encourages open dialogue, publishes an open-access peer- reviewed journal centralizing associated literature, and generally serves to guide the field. A “network of data networks” and regional “citizen-science centers” could also maintain interconnected databases listing pro- grams, best practices, standardized protocols, and vetted training materials; deliver cyberinfrastructure support for data management; offer complex analysis and visualization tools; and provide forums for theoretical, empiri- cal, and technological advances. (p. 303)

This requirement was also identified by one of the experts (Exp1), who said that id needs an association which bundles all the different efforts, research papers, outcomes etc. As citizen science is such a wide filed it requires a centre that tries to provide the relevant information on one place, provides also guidance, links to the projects.

In addition this association also needs to address and elaborate on questions like IPR issues and how to deal with the collected data (who has access and the right to use them, where are they saved etc.). Funding agencies like the EC should support this work of elaborating a framework of citizen science involving those agencies who are really involved in citizen science since long time.

3. Contributors

3. 1. Formal contributors

3.1.1. Experts interviews

Name	Institution	Profile
David Anderson	Space Science Laboratory, University of California	Project director of BOINC
Steven Bamford	University of Nottingham	Science Director of the Citizen Science Alliance
Steven Bishop	University College London	Professor, FuturICT Management coordinator
David Curren	www.openscientist.org	Writer about Citizen Science and Volunteer
Grey Francois	Citizen Cyberscience Centre (CCC) Tsinghua University in Beijing	Coordinator of CCC
Drew Hemment	FutureEverything	Founder and CEO
Ben Segal	Citizen Cyberscience Centre Honorary CERN staff member	Senior Advisor & Mentor
Jennifer Shirk	The Cornell Lab of Ornithology	Project Leader CitizenScience.org

3. 1.2. Open Call for contributions

Name	Institution	Profile

Eduardo Actis, Laura Ferrando, Mónica Lara, Pilar Tigeras	CSIC	Scientific Culture Officer
Rodríguez Álvaro		Researcher
Chandra Clarke	Citizen Science Center	Volunteer
Karl Donert	EUROGEO	Educator
Yuri Gordienko	G.V.Kurdyumov Institute for Metal Physics (IMP), National Academy of Sciences	Researcher
Muki Haklay	UCL	Researcher
Susanne Hecker, Monique Luckas, Doreen Werner, Angelika Wurbs	Leibniz Centre for Agricultural Landscape Research	Researcher
Melinda Hughes-Wert	Nature Abounds	Non-profit President and Citizen-Science Program Manager
Coral Victoria de la Iglesia Meleiro	FAMUNCYT	Scientific programs coordinator
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Adam McNamara	Ariadne Computing Ltd.	Innovator
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Jonathan Silvertown	The Open University	Researcher
Francisco Vigalondo	University of Saragosse	Researcher
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3.1.3. Registered participants for the virtual workshop

Name	Institution	Profile
Kirsti Ala Mutka	EC	Policy Officer
Rosa Arias		
James Borrell	http://www.jamesborrell.com/	Vlogs about fieldwork, motivation, adventure and getting involved.
Pieter van Boheemen	Waag Society's Open Wetlab	Open Biotech
Virginia Brussa		crisismapper
Caren Cooper	http://www.carencooper.com/	wildlife ecology and conservation
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Kshitiz Khanal		
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3.2. Informal contributors:

In addition we want to thank all our informal contacts in our organisations and networks for all their input during fruitful discussions and experience sharing.

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ANNEX 1 – INFORMED CONSENT

SOCIETIC
SOCiety as Infrastructure for E-Science via technology, innovation and creativity

European Commission Seventh Framework Project
(Coordination and Support Action – Grant Agreement No. 312902)

Declaration of Consent

:name of participant

Fermin Serrano Sanz (fserrano@unizar.es) :name of contact

Instituto de Biocomputacion y Fisica de Sistemas Complejos
C/ Mariano Esquillor s/n Edificio I+D Despacho 2.2.09
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Executive Summary

Dr. Joana Namorado from the Directorate Health-DG RTD – European Commission, responsible for Ethics and Gender Issues, provides good guidance on informed consent (Namorado 2011, page 28). An informed consent has to answer and consider following questions:

- What is the research? Purpose, duration and description of project aims.
- foreseen risks and benefits, are there alternatives
- confidentiality, treatment/ compensation and information
- contact for rights and claims; injury to the subject
- voluntary participation or Condition of participation
- no penalty or loss on stopping

The following informed consent of Societic gives detailed answers to the above mentioned questions to make sure, that the rights of each participant are ensured.

1. Project aims

Citizen science is an innovative concept to involve the general public in scientific processes. One of the best ways to help people understand science is by letting them participate in scientific research and experiments. This is what citizen science tries to achieve.

The project SOCIETIC (SOCiety as Infrastructure for E-science via Technology, Innovation and Creativity) will coordinate all agents involved in the citizen science process, setting the basis for this new open science paradigm. The project will promote the usage of science infrastructures composed of dedicated and external resources, including professional and amateur scientists. SOCIETIC will set-up a network where infrastructure providers and researchers will recruit volunteers from a general public to perform science at home.

Individual citizens will contribute to scientific studies with their own knowledge and resources participating in an active way. Citizens will be donors by connecting their own computing resources, such us smart phones, desktop computers or other devices to science infrastructure. But, citizens will also be actors when they actively participate in the scientific process, in different phases: from short and easy activities to the inception of new research lines, leading people driven developments or in the development of software components, similar to open-source communities. We propose to open e-science to the people, even considering the knowledge and the time of the citizen scientists as part of the resources that constitute the e-infrastructures, and call this enhanced citizen-based infrastructure “c-infrastructure”.

The main objectives of the project:

- Foster interaction and coordination between all citizen-science actors: researchers, resources providers, system administrators, and volunteers from the society. Offering common tools and workspaces for all of them, by deploying society-pull research and presenting results in an attractive way, including artistic will create a common interface and innovation oriented features.

- Promotion of the capabilities of the c-infrastructures, not only in general terms but also presenting concrete results. Our aim is to convince other research infrastructure providers and users, specialized researchers and people at home that it is possible to make top-level science by opening the labs and easing interaction and contribution from amateur scientists.
- Integration of existing solutions and users communities that aim to share experiences and innovate creating common solutions. Apart from existing citizen science practices this project will also deploy a set of concrete experiments that focus on specific topics and will add new resources to the available research infrastructures.
- Compilation and sharing of best user practices oriented towards research infrastructures users and providers, as well as policy--makers recommendations for implementing citizen science.

10Storage of personal data

During the course of the project, personal data will be collected a number of times by means of observation, interviews and group discussions. This data is used to develop and to evaluate the success criteria for citizen-science and dissemination activities undertaken in the project SOCIETIC.

The data will be used only within the project framework of SOCIETIC, and will not be made accessible for any third party. It will not be stored after the end of the project.

The data do not contain the names or addresses of participants and will be edited for full anonymity before being processed (e.g. in project reports).

11Audiovisual material

Videos and photographs taken during the course of the project may contain the pictures of participants. SOCIETIC may use these videos and photographs in public forums, on websites or in conferences in order to inform about the project. Each participant allows the project SOCIETIC to use the said materials.

Each participant may demand removal of photographs or videos from public forums and websites by simple request. Subject to technical feasibility, SOCIETIC agrees to remove the requested items without delay.

12Instructions and advice

An identified contact person will be available for project-related instructions and advice. Each participant may gladly discuss questions and problems with the contact person at any time.

13Code of Conduct

Participation in SOCIETIC is meant to be as agreeable and pleasant as possible for all those involved. Therefore, all participants agree to respect the following rules:

- Racism and discrimination: racist comments, discrimination on the basis of sex, age, or disability, publication of racist or sexist pictures and insulting persons are strictly banned.
- SOCIETIC may not be abused for political, religious or advertising purposes.

- Infringements of copyright laws are not permitted.
- It is only allowed to publish one's own texts and pictures. Publishing pictures from the account of another person is not permitted without this person's consent.

All participants' conduct towards other users should always be appropriate and never offensive or depreciating.

14 Consent

After having stated these general conditions and rules, we are looking forward to a good cooperation and positive project results. We would like to thank you in advance for your participation in the project SOCIETIC.

The undersigned declare that they understand and consent to the conditions and rules of SOCIETIC.

Both parties receive a copy of this declaration of consent.

Participant's signature:

Zaragoza, day/month/year

Contact's signature:

Zaragoza, day/month/year

Fermin Serrano Sanz

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15 Bibliography

Powerpoint Presentation from Dr. Joana Namorado, Ethics, Gender Issues Directorate Health-DG RTD – European Commission at the Austrian National Contact Point FFG: http://rp7.ffg.at/upload/medialibrary/Namorado_Ethics.pdf (September 2011, page 28).