Co-designing Citizen Social Science for Collective Action

#2.1

REPORT ON STATE OF THE ART OF CITIZEN SOCIAL SCIENCE

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List of Abbreviations

ACUMAR	Matanza-Riachuelo Basin Authority
CBPR	Community-based Participatory Research
CompSS	Computational Social Science
CS	Citizen Science
CSO	Civil society organisation
CSS	Citizen Social Science
EC	European Commission
ECSA	European Citizen Science Association
FARN	Fundación Ambiente y Recursos Naturales
FAIR	Findability, Accessibility, Interoperability, Reusability
FSMC	Federació Salut Mental Catalunya
GIS	Geographic Information Systems
GPS	Global Positioning System
HCI	Human-Computer Interaction
ICT	Information and Communication Technology
KC	Knowledge Coalition
MIT	Massachusetts Institute of Technology
ORFG	Open Research Founders Group
PAR	Participatory Action Research

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PD	Participatory Design
PLA	Participatory Learning and Action
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
R&I Action	Research and Innovation Action
RRI	Responsible Research and Innovation
RwL	Real-world Laboratory
SDG	Sustainable development goal
STS	Science and Technology Studies
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
WHO	World Health Organisation
WoS	Web of Science
WP	Work package

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Executive Summary

CoAct proposes a new approach to face social global concerns with Research and Innovation Actions (R&I Actions) related to mental health care, youth employment, environmental justice and gender equality by engaging citizens as co-researchers. Our approach represents a new understanding of Citizen Social Science (CSS), understood here as participatory research co-designed and directly driven by citizen groups sharing a social concern. The overall objective of CoAct is to develop and demonstrate the scientific relevance and social impact of CSS, which is to date an underexplored area of Citizen Science (CS).

This document constitutes Deliverable 2.1 'Report on State of the Art of Citizen Social Science' of Work Package 2 (WP2), which is dedicated to the CSS foundations. It provides a starting point towards a common framework and a common arena to better elaborate the various characteristics of CSS. CoAct wants to contribute to the debate by catalysing the discussion and enlarging the CSS community. This effort is unprecedented in the CS and the Social Science worlds and it is expected to later result into new open materials (for citizens, policy makers, NGOs and academics) and new transdisciplinary methodologies to widen the impact of CS.

This report discusses CSS as a component of CS, with its main characteristics that citizens act as co-researchers conducting research on social issues with the aim of achieving transformative and sustainable impact with the research. CSS is however emerging from at three streams: from the broader spectrum of a CS community; from a participatory research background in the social sciences and humanities and moreover directly from Citizen Organizations (CSOs), who initiate and lead research. Thus, the report assembles a detailed review of a vast variety of methodologies, methods, approaches and practices to be applicated to R&I Actions and with the aim of delineating a theoretical and methodological framework for CSS. As a result, foundational aspects, challenges and critical topics for further discussion are identified.

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1. Introduction

This document constitutes Deliverable 2.1 'Report on State of the Art of Citizen Social Science' within the Work Package 2 (WP2) 'Citizen Social Science Foundations' of CoAct. The overarching objective of CoAct is to demonstrate the scientific relevance of the social dimensions of Citizen Science (CS) and to develop a methodological framework for Citizen Social Science (CSS), which is to date an underexplored area. With CoAct, we want to explore and add new suitable and benefitting approaches to the more general debate on CS by putting citizens and their social concerns in the centre of the research. Thus, CoAct proposes an explicit participatory and inclusive approach to conduct research on urgent social issues in which citizen groups act as co-researchers.

This state-of-the-art report identifies potential participatory approaches and strategies that the several partners of CoAct can contribute with. They provide particular starting points for CoAct's dedicated work to elaborate and delineate an overarching theoretical and methodological framework for CSS in the further course of the project. Therefore, on the one hand, the report provides a first effort to map and share the internal capacities within the consortium. With the report we aim to strengthen the social dimensions of CS research by considering the different perspectives and expertise of the academic and non-academic consortium partners which can better shape the planned Research and Innovation Actions (R&I Actions) on four urgent social issues: mental health; youth unemployment; environmental justice; and gender equality.

On the other hand, CoAct will contribute with this deliverable to the emerging debate on CSS by catalysing discussions within CS as well as the Social Sciences and Humanities. The objective here is to be as inclusive as possible in providing a common ground for a CSS methodological framework beyond CoAct. Therefore, we start with a broad definition of CSS, as a participatory research co-designed and directly driven by citizens groups sharing a social concern. Moreover, with the term 'citizens', in contrast to an exclusive national legal status of 'citizenship', we rather follow an understanding of a socially constructed political subjectivity that includes also 'none-citizens' (e.g. Gonzales & Sigona, 2017).

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The following question provided a general analytical lens for discussing the state of the art: Which theoretical, epistemological and methodological components for a CSS foundation can be found in the literature? Furthermore, a couple of subordinated questions have been articulated in order to specify the review of candidate methodologies, methods and approaches for CSS research in the R&I Actions: What is the role of participation? How is social impact discussed? What are critical aspects for CSS? Which tools and strategies enable intensified participation and research co-design? What are challenges and crucial topics for further discussion and development in relation to stablished research areas?

Accordingly, the report is structured as follows: In *Chapter 2,* we describe CS, social sciences and Civil Society Organisations (CSO) as our three points of departure for exploring CSS with. *Chapter 3* provides an overview conducted by a quantitative bibliometric analysis of all papers that we assembled as a consortium for the report regarding the frequency of specific shared terms and its relations. Here we seek to discover structures, connections and clusters of shared terms between the different approaches and to identify which are the key terms that better connect the different cultures within the consortia. *Chapter 4* contains the main body of the state-of-the-art review of promising participatory methodologies, methods and approaches for applying in the R&I Actions and beyond. *Chapter 5* draws on these discussions and assembles foundations for CSS research, potential tools as well as challenges and crucial topics identified during the review process.

2. Three points of departure for Citizen Social Science

In recent years, CSS has become an emerging topic in the CS debates (Kasperowski & Kullenberg, 2019; Tauginienė et al., 2020). The term 'Citizen Social Science' first was coined within the general framework of CS and its research philosophies, knowledge claims, and application contexts (Dadich, 2014; Purdam, 2014). However, CSS cannot be seen as a completely new approach, methodology or method. Rather it is closely linked to and derives from various fields of the social sciences and the humanities (Schäfer & Kieslinger, 2016; Pettibone & Ziegler, 2016; Darch, 2017; Heiss & Matthes,

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2017; Hecker et al., 2018; Bonhoure et al., 2019; Fischer, 2019; Kythreotis et al., 2019; Agostini et al., 2019; Mayer et al., 2020). But as Mahr et al. point out 'the citizen science scene is still in a phase of self-identification and development' (2018, 102). This explorational state seems even more relevant for social scientists conducting CS research (Franzen & Hilbrich, 2015). Since there is a vast variety of methodologies and approaches which are not yet sharing a common ground, there is clearly a need for further clarification of the foundations of CSS from which common framework and characteristics could be developed.

Therefore, as shown in Figure 1, we indicated three major sources for CSS in our attempt to delineate a methodological framework for further developing CSS research in the course of CoAct: First, an important reference point is the already existing and enfolded discourse about CSS in the CS community (Chap. 2.1). Second, from various fields of social sciences and humanities a vast variety of participatory methodologies, methods and approaches have been established in the last five decades that provide a fruitful source for CSS research and a systematic integration in a further development of a CSS methodological framework (Chap. 2.2). Finally, we consider research initiated and conducted by citizens, CSOs, and social activists as a third major resource for CSS with an special focus on citizen-led research that directly derives from particular social issues provides substantial know-how for co-creational and co-designed CSS research (Chap. 2.3).

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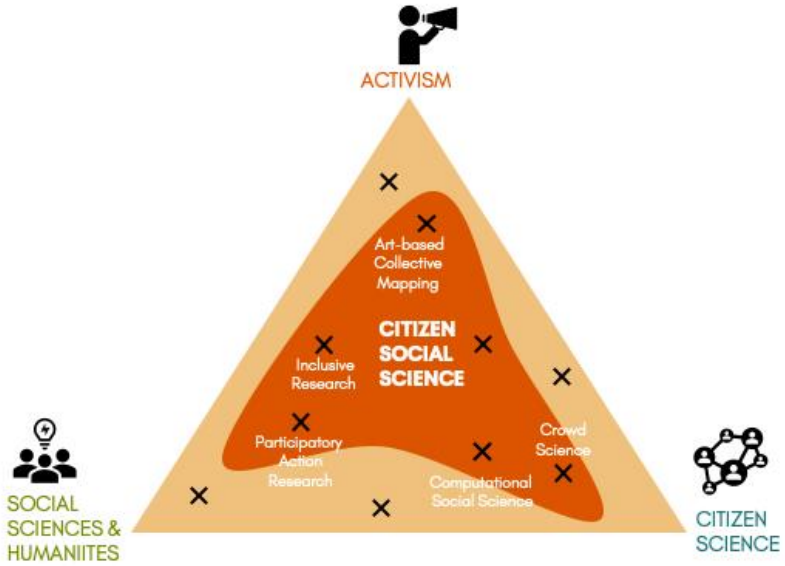

Figure 1: Three points of departure for Citizen Social Science

2.1. Citizen Science – A starting point

Under the umbrella term 'citizen science', research has been conducted for more than a quarter of a century. Citizen science 'is a common name for a wide range of [participatory] activities and practices. […] There is little doubt that a project with an open call to a wide range of volunteers to take part in either data collection or data analysis of a clearly defined research hypothesis will be recognized as citizen science. However, this is only one type within a large set of activities, practices and forms of participation, resulting in diverging views about what is – and isn't – citizen science. Because of these differences in disciplinary and cultural contexts, attempting to define a universal set of rules for exclusion or inclusion is difficult, and might even limit the advancement of the field.' (Haklay et al., 2020). A working group of the European Citizen Science Association (ECSA) proposed ten principles of citizen science some years ago (ECSA, 2015; Robinson et al., 2018). They are recently expanded in a collective effort to identify characteristics of CS 'based on views expressed by researchers, practitioners, public officials and the wider public' (Haklay et al., 2020). Both contributions serve as

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guidelines for planning, conducting, and evaluating CS projects and different streams of CS clearly emerge.

On the one hand, CS initiated a shift towards a renegotiation of the relationship between science and technology, and, on the other hand, of society and the public (Irwin, 1995; Kasemir et al., 2003; Leshner, 2003; Powell & Collin, 2009; Ottinger, 2010). From this bottom-up perspective CS is about empowerment and citizens' active participation in science, technology and research. The contributions of CS researchers range from questions that are mostly provided by universities and research centres to the independent self-organization of citizen scientists, for example in pop-up science shops or in projects on critical monitoring of environmental parameters for sustainability and urban research.

On the other hand, another perspective on CS derives from crowd science-approach that aims to include as many participants as possible in the data collections and analysis (Bonney et al., 2014). Participation is here much stronger top-down oriented, with scientists leading the research and citizens contributing to the data collection and analysis. Examples include the Cornell Lab of Ornithology project 'eBird' with birdwatchers ('eBirders') from around the world sharing observations with professional ornithologists, or the 'GalaxyZoo' project that invites citizens to participate in the classification of galaxies, as well as projects that enlist the help of citizen scientists to monitor air quality to promote social change (Brussel & Huyse, 2018) and light pollution (Schroer et al., 2017). Albeit, there is plenty of potential for development in the approach of crowd science and the application of digital tools, current CSS research is mostly conducted on a smaller scale, in small groups or face-to-face.

The term 'Citizen Social Science' appears in different notions in the CS community only in the last six years with just a few scholars explicitly using the term (Dadich, 2014; Purdam, 2014; Vallejos et al., 2015; Richardson, 2016; Housley, 2018; Kythreotis et al. 2018; Mayer et al., 2018; Bonhoure et al. 2019; Thomas, Scheller & Schröder, forthcoming). Besides participation, the inclusion of minority and

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groups in vulnerable positions, provision of research with social impact, as well as providing data and knowledge for policy making have been identified as current key challenges of CSS (Eitzel et al., 2017). In a collaborative and participatory way, citizen and academic researchers raise, inter alia, scientific questions together, create research designs, collect data for analysis, evaluate and disseminate the results and translating those results into practice (Mayer et al., 2018). The insertion of the word 'social' in CS is intended to indicate that further clarification and development is necessary when it comes to investigating social topics and issues.

CSS, understood as participatory research co-designed and directly driven by citizen groups sharing a social concern, can be already identified in the fields of environmental issues (Irvin, 1995; Dickinson & Bonney, 2012), environmental monitoring (Conrad & Hilchey, 2011) and sustainable development goals (SDGs) (Kasemir et al., 2003; Vohland et al., 2019; Millar & Searcy, 2020), public health (Den Broeder et al., 2016; Cigarini et al., 2018; Laskaris et al., 2019), education (Müller et al., 2012; Wöhrer et al., 2017; Fam, Neuhauser & Gibbs, 2018), archaeological excavation (Gibb, 2019), and community organizing (Thomas, Scheller & Schröder, forthcoming) just to name a few.

2.2. Social Sciences – Participation and beyond

Social sciences open the field of CS projects towards the social world, social topics, and social issues with direct relevance for citizens as it is their own lifeworld. Since the historical sources of CS origins mainly in natural science, the discussion of the development of a CSS methodology is still evolving but also has accelerated in recent years (Tauginienė et al., 2020; Mahr et al., 2018; Mayer et al., 2018). We would argue that the epistemological difference of natural and social sciences could productively interact in a CSS methodological framework. Such a conversion could lead to the evolution and invention of new methodological tools and concepts that potentially improve research of multifaceted issues, that address i.e. an environmental, a socio-political, economic, a personal, and a scientific dimension. Therefore, the social sciences in its broadest sense constitutes a central starting point for CSS. Social science theories as well as qualitative and quantitative research methodologies

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can substantially contribute to the exploration of social concerns in CSS (Creswell, 2014), on the one hand, and to the attempt of further developing and improving a methodological framework for CSS, on the other hand.

Social sciences add a further perspective on the social dimension that questions any objective givenness of social reality itself. Its objects are social constructions of actors, socio-cultural meaning, and the interpretation of the symbolic layer in various perceptions and communication among members of the society (Denzin & Lincoln, 2011; Flick, 2020). Social sciences provide methodologies, methods and tools for both counting and measuring of social reality to give explanations for the occurrence of social phenomena and for interpreting and understanding social reality based on symbolic meaning and communication.

Therefore, social sciences allow a further extension of CS research interests not only into shared social concerns by co-researchers but also into the realm of sense-making practices in communication and social action. To get into an exchange about what in the social world counts as true and constitutes worldview in research, communicative and self-reflexive practices are necessary. Social sciences provide a full range of research tools such as experiments and surveys, interviews and group discussion, ethnographical methods and participant observation among others that makes this symbolic and interpretive dimension of social reality accessible for science (e.g. Grønmo, 2019). Because social constructions and meaning are always a product of societal interpretation processes among different actors, the analysis of and a sensitivity for power relations must be reflected as an epistemological prerequisite (Berger & Luckmann, 1966). For making the normative dimensions of the social world transparent and for a critical analysis of power disbalances, the social science debate on research ethics could also contribute productively.

Furthermore, social sciences provide longstanding experiences and expertise to conduct participatory research so that a substantial contribution to the debate on collaborative research between scientists and citizens for CS can be expected. These participatory approaches have proven their capacity of

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bringing forward meaningful empirical contributions of citizens themselves and shifting the role of research subjects for many decades (Kemmis & McTaggart, 2000; Reason & Bradbury, 2008; Rowell et al., 2017; Bergold & Thomas, 2012; Unger, 2014). *First*, the application of participatory research approaches of the social sciences in the R&I Action brings a vast variety of different established and developed methodologies, methods and approaches for further developing open, co-designed, co-created research by citizen groups sharing a social concern. *Second*, we would argue that a careful selection and review of methodologies, methods and approaches in the social sciences and related scientific fields helps to depict the epistemological, theoretical and methodologic specificity of CSS. *Third*, regarding CoAct's objective of developing a delineated methodological framework for CSS, the social sciences also provide a high potential towards truly transdisciplinary research.

2.3. CSOs and Activism – Social impact and sustainable change

Activism and CSOs constitute a third point of departure for CSS. Here the research interest emerges directly form the confrontation with a particular social issue, like in our cases mental health, youth unemployment, environmental justice or gender equality. Thus, the R&I Actions emphasize a strong focus on social impact to initiate social change, i.e. towards collective actions, policy measures and community self-organizing. From this perspective, CSS research topics are immediately relevant for citizens, with their social concerns and their everyday lives which are accordingly placed at the centre of the research. Moreover, the divisions between activist and scientist are often blurry, i.e. with scientist activists (Haraway, 1988; Militant Research Collective, 2013; Carstensen et al., 2014) or scientists as supporters and partners in coalitions of citizens (RTTC, 2014; Sitrin, 2012).

The CSO or activist motivation for conducting research or participating in the scientific examination of social topics highly correlates with civil society engagement and political activism. From our perspective this defines another specific aspect of CSS, that citizen initiated and led research is directly connecting (social) science with the real-world experience and expertise. Here CSS is about evidence-based knowledge production that could increase the social impact and the relevance of

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research topics for citizens besides the scientific impact. In particular, the (participatory) social sciences – with theory-based approaches and elaborated methodological frameworks – have gained interest by activists for approaching a particular social issue in its specific social context (e.g. PTH, 2011; RTTC, 2014; Iconoclasistas, 2018). Social science methodologies and social theories can become instruments for a collaborative production of contextual empirically and socially robust knowledge that would be recognized in political decisions, which would provide an 'opportunity for empowerment' (Wyler & Haklay, 2018).

3. Bibliometrics for building a CSS framework

In this chapter we present the results of our quantitative bibliometric analysis that we have carried out with the aim of exploring potential connections and common ground of the transdisciplinary CoAct consortium regarding the literature that we collectively assembled for the report. First, we will look at the context and the background of the term 'citizen science' and 'citizen social science' by analysing the Web of Science (WoS) database [1] (Chap. 3.1). Second, by applying a quantitative sociolinguistic analysis method for looking sociolinguistic analysis we are looking at the diversity in language that is being used across our bibliographic references (Chap. 3.2). And finally, we present the results of the network analysis of the frequency of specific shared terms and its relations in all the references in this report (Chap. 3.3).

3.1. Context and background

According to the WoS *4,233 publications* have been using explicitly the term "citizen science" in the title, abstract or in keywords (consulted 26 June 2020). The WoS website also allows for a quick bibliometric analysis. The number of publications is exponentially growing during the last decade even when we normalize them with respect the number of publications with the term 'science' (see Fig. 2). These publications are scattered among the research domains of WoS in the following way: 'science technology' (3,864 records), 'social sciences' (1,634 records), 'arts and humanities' (197

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records). The 'environmental sciences and ecology', 'biodiversity', 'conservation' and 'zoology' research areas in the WoS classification broadly concentrate 38% of the records (see Fig. 3). The academic institutions signing these research articles mostly belong to United Kingdom and United States (see Fig. 4). According to the WoS database, journals publishing CS researches mostly belong to environmental sciences but there are other journals that are labelled within 'multidisciplinary sciences' tag (e.g. Plos One and Scientific Reports). Similar results are obtained by some publications with a less updated database but with a more profound analysis. Follett and Strezov (2015) studied usage and publication patterns in CS based research and already found an exponential growth and encouraged cross-fertilization between the different discipline in future CS publications. Kullenberg and Kaperowski (2016) 'aim of giving a scientometric description of what the concept of CS entails' combining quantitative and qualitative methods and found scarce number of publications in the social sciences. However, Kullenberg and Kaperowski (2016) identified a line of research relating to social sciences and epidemiology, which studies and facilitates public participation in relation to environmental issues and health. The most recent study performs keyword co-occurrence analysis and identify four major clusters emerge when considering categories detected in the literature on CS (Bautista-Puig et al, 2019). The authors label them as 'health', 'biology', 'geography' and 'public', respectively.

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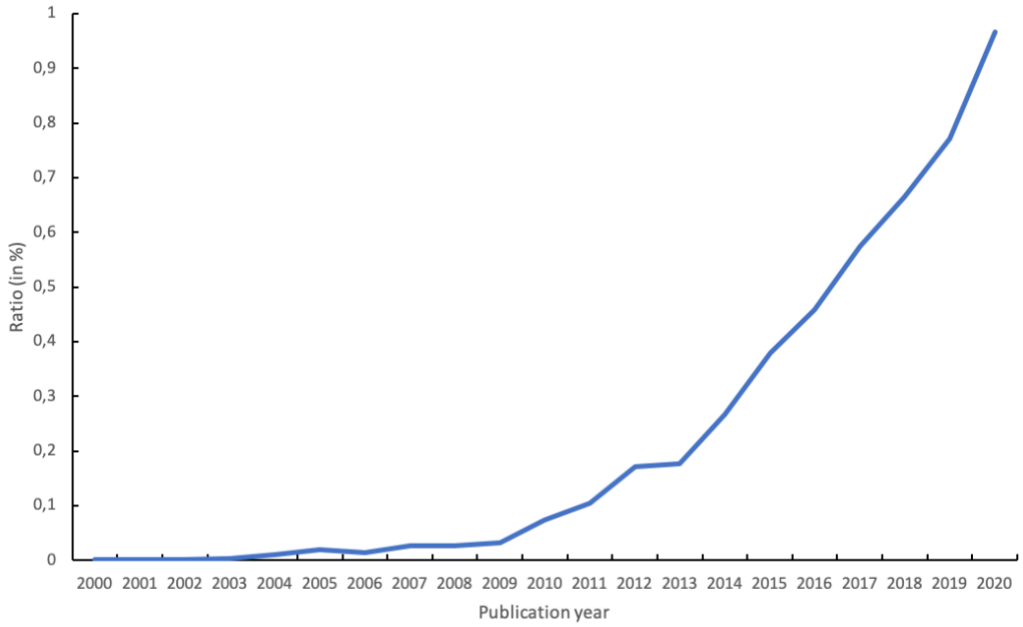

Figure 2: Evolution of the ratio between the number of publications with the term 'citizen science' and number of publications with the term 'science' in the several years. Source WoS (retrieved 26 June 2020)

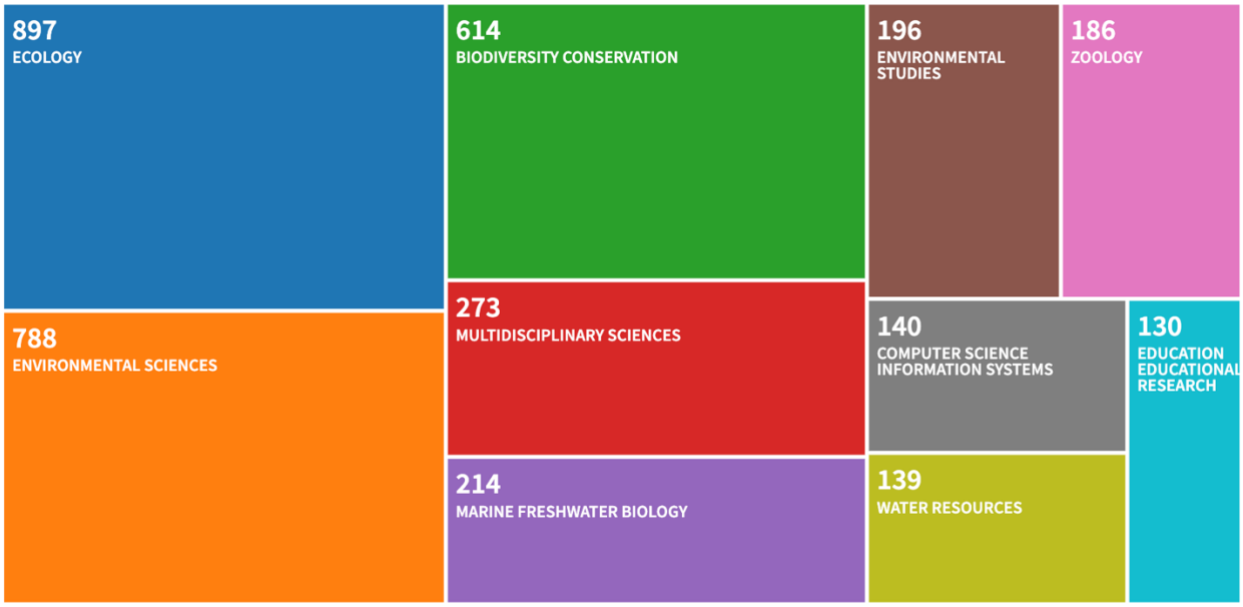

Figure 3: Number of publications with the term 'citizen science' in several research areas defined by the WoS database. Source WoS (retrieved 26 June 2020)

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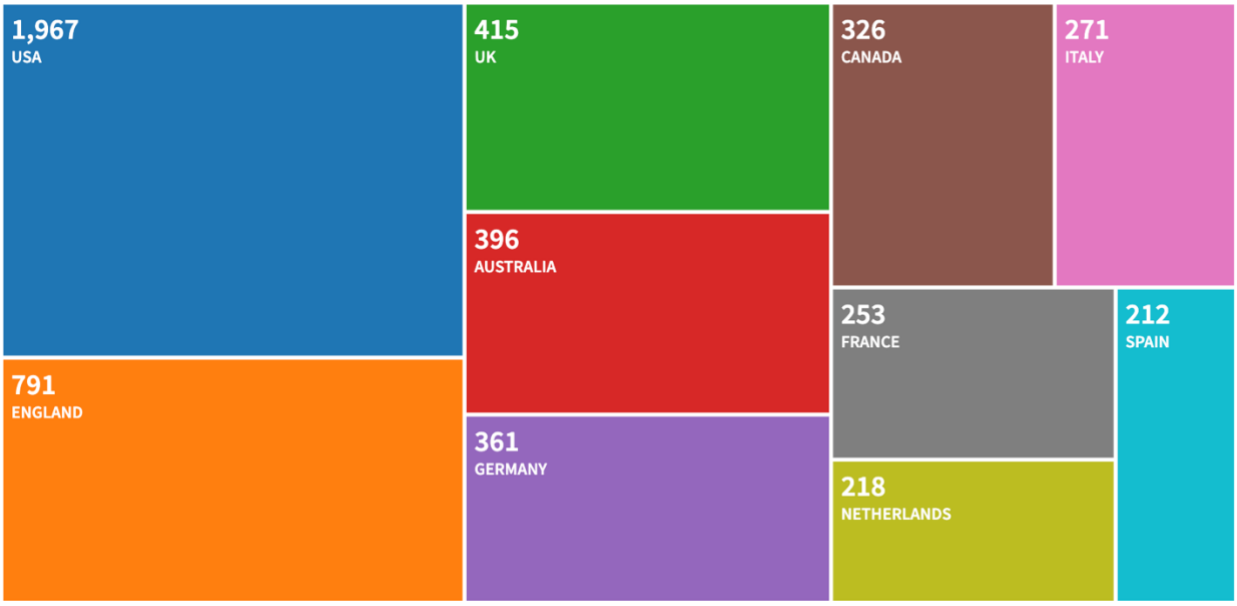

Figure 4: Number of publications with the term 'citizen science' as a function of the countries signing the research papers. Source WoS (retrieved 26 June 2020)

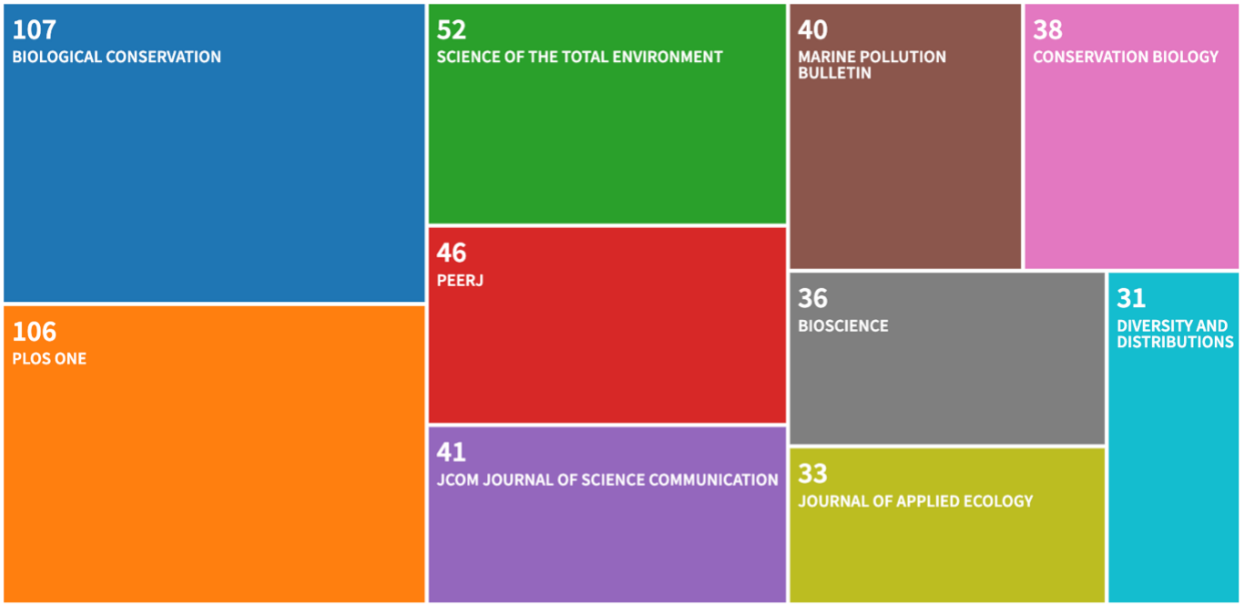

Figure 5: Number of publications with the term 'citizen science' in different journals. Source WoS (retrieved 26 June 2020)

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In a recent publication, Tauginiené et al. (2020) used 'a meta-synthesis approach to explore how CS is practised in the so far less addressed social sciences and humanities by focusing on the role of the citizens, the goals and approaches of the projects, the tasks in which citizens are engaged and their gains […] Findings indicate that social sciences are gaining more acknowledgment within interdisciplinary CS projects by addressing 'wicked' urgent problems of human behaviour and agency, while humanities are in quest of a better-defined locus in CS. [..] Social sciences and humanities still face considerable barriers to infiltrate CS.' Furthermore, a quick search of the term 'citizen social science' in WoS indicates clearly that CSS would need further development and configuration. The number of publications reported are limited to six publications (retrieved 26 June 2020) and, even within a very short number of publications, it is clear to observe that there is still no common ground for CSS (see Table 1).

The shape of the term will surely take clearer form in WoS in future, when CCS could be expected to be more extensively used. In the meantime, we have opted to do the following a bottom-up exercise starting from internal capacities in CoAct consortia. We thus have made an analysis of the references provided by the different partners when writing the current deliverable about the foundations of CSS. Diversity in the consortia is therefore reflected. It can thus be seen as a positive driving force on how CoAct will be building its own notion of CSS. In this way, we have wanted to put into value the different backgrounds, to start imagining spaces for transdisciplinarity or to explore opportunities for interdisciplinarity. In particular, we consider:

(1) the degree of diversity and variety of terms that could be considered when building CoAct notion of CSS;
(2) the common or mostly shared terms we are using albeit belonging to different research fields;
(3) the set of terms mostly connected among them (clusters) and those less connected with key terms.

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1. Purdam, K. (2014). Citizen social science and citizen data? Methodological and ethical challenges for social research. Current sociology, 62(3), 374-392.
2. Dadich, A. (2014). Citizen social science: a methodology to facilitate and evaluate workplace learning in continuing interprofessional education. Journal of Interprofessional Care, 28(3), 194-199.
3. Kythreotis, A. P., Mantyka-Pringle, C., Mercer, T. G., Whitmarsh, L. E., Corner, A., Paavola, J., ... & Castree, N. (2019). Citizen social science for more integrative and effective climate action: A science-policy perspective. *Frontiers in Environmental Science*, *7*, 10.
4. Housley, W. (2018). Conversation analysis, publics, practitioners and citizen social science. Discourse Studies, 20(3), 431-437.
5. Vallejos, E. P., Koene, A., Carter, C. J., Statache, R., Adolphs, S., O'Malley, C., ... & Gleibs, I. Insights from a Workshop on Social Media Analysis and Mental Health: Putting People at the Centre of Human Data. Conference: 2nd European Conference on Social Media, 2015.
6. Richardson, L. (2016). Citizen social science and policy making. Evidence-Based Policy Making in the Social Sciences: Methods That Matter, 207.

Table 1: List of references in the WoS database with term 'citizen social science' (retrieved 26 June 2020)

3.2. Diversity in language being used across the bibliographic references

For analysing the diversity in language, we analyse the rank-frequency distribution and observe whether it applies the Zipf's law, which is an empirical law originally formulated in terms of quantitative linguistics. It states that the frequency of any word is inversely proportional to its rank in a frequency table (Zipf, 1949). Thus, the most frequent word will occur approximately twice as often as the second most frequent word, three times as often as the third most frequent word, etc. The rank-frequency distribution in human speech therefore follows an inverse relation (a power law decay with exponent one) due to its unique complexity and diversity. The slow decay, an exponent smaller than one, could give reason of even more diversity or alternatively could attributed to a speech characterized by multiple topics and the absence of consistent subject (Ferrer I Cancho, 2005).

As a first approximation to the body of literature we are handling, it can be thus interesting to look at its rank-frequency and compare it with respect cases such as single-author texts (Ferrer I Cancho,

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2005). The fitting with our bibliography provides a nice power-law fit. Exponent is however just a bit below one. The fit gives an exponent equal to 0.9257+/-0.0018. This means that the emerging joint word frequency is effectively less consistent than single-authored texts but differences does not seem to be relevant (see Fig. 6).

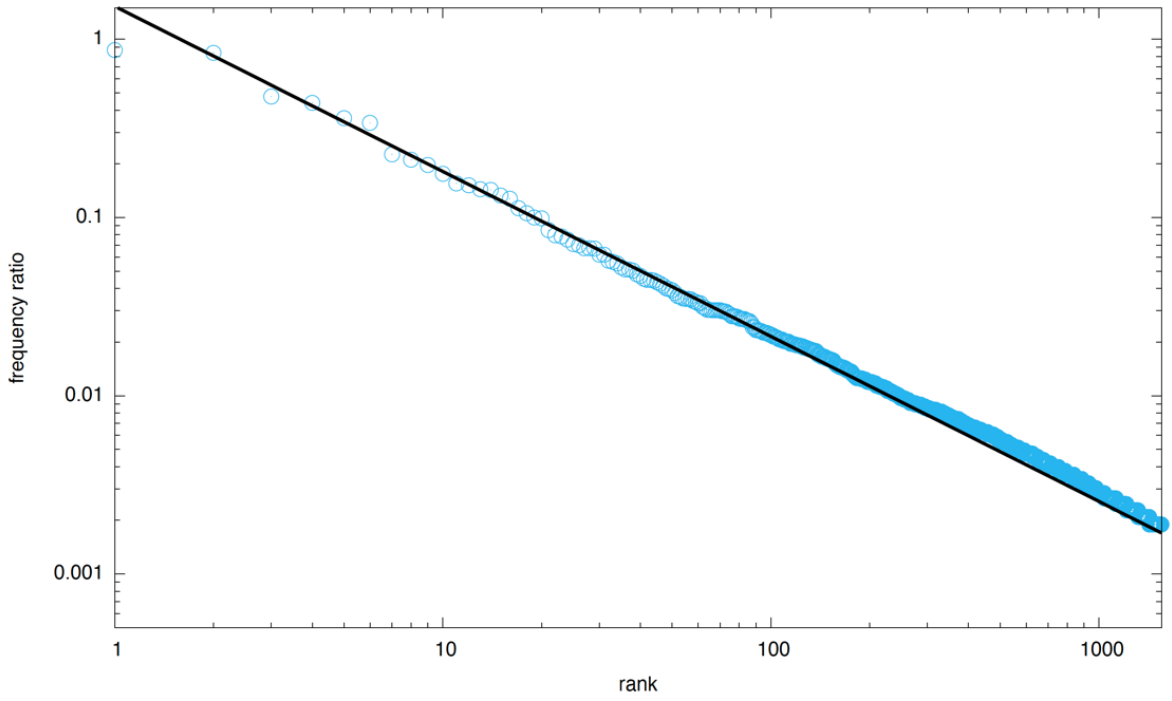

Figure 6: Rank-frequency curve of the words in title and abstract of our reference list in blue dots. The fitting curve (solid line) takes an power law exponent very close to 1 (the fit gives an exponent value of 0.9257+/-0.0018)

3.3. Network analysis

VOSviewer[2] allows to make a text mining visualization that helps to analyse the relationship between the terms used in our bibliographic database (for details on network analysis procedure see Appendix).

It is however needed some careful term identification stage that yields a set of noun phrases, or terms, that have been identified in the text data through natural language processing algorithms. The

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term identification stage includes the following steps: (1) sentence detection (the text data is split up into sentences); (2) part-of-speech tagging (each word is assigned a part of speech, such as verb, noun, adjective, preposition, and so on) (3) noun phrase identification (as a sequence of one or more consecutive words within a sentence) considering only the longest possible noun phrases that can be found in a sentence (a noun phrase cannot include a preposition). Unification of noun phrases is accomplished by removing most non-alphanumeric characters, by removing accents from characters, by converting upper case characters to lower case, and by converting plural noun phrases to singular. Plural to singular conversion is done by examining the last word in a noun phrase. If the last word is a plural noun, it is converted to singular.

In the second stage, starting from the set of identified terms, a selection of terms is made. The selection is made by excluding terms with a small number of occurrences (fewer than 10 occurrences are excluded) and then takes the 60% most frequent thus finally keeping 202 references. Eventually, we have manually removed terms such as 'end', 'review', 'part', 'thing' while others such as 'research process' are downgraded to a simple word ('research' in this case). This results to a final list of 163 terms in the network analysis presented in the three different layouts.

3.3.1. Co-occurrence: Cluster density visualization

We first pay attention to the emerging cluster density (Fig. 7). The algorithms for identifying clusters detects between 3 and 4 groups (one quite small). We have finally opted to choose the algorithm that takes 4 groups because it is more robust, and it appears to be more informative. Each cluster has a different colour. The weight given to the colour is determined by the number of items belonging to that cluster in the neighbourhood of the point. The size of the words is proportional to its frequency in the different references. The four clusters identified are:

(1) (Yellow, citizen science) The two words that dominate this cluster are 'citizen science' (250 times) and 'science' (323). 'citizen science' is closely accompanied by terms such as 'data' (190), 'volunteer', 'web', 'citizen', 'map'. It is also interesting to see that less central terms like

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'public engagement' are those that delimits the green cluster while those words closer to (blue) cluster are terms such as 'barrier', 'control', 'service' or 'support'.

(2) (Green, Makerspace/Innovation) This a quite ample area with wide diversity of terms. It can be however possible to highlight the terms 'innovation' and 'makerspace'. In general, the cluster brings several notions for infrastructure and methods, especially those terms closer to the CS cluster (blue) which are in general related to CompSS literature (see next section). The other important aspect is to see its connection with red cluster with terms such as 'integration', 'transdisciplinarity', and 'openness'.

(3) (Red, Action Research) Most relevant term is 'action research' (150 times, the 4th most frequent word in the network) accompanied with several terms such as 'participatory action research' sparse in an ample area. This cluster is the most distant cluster with respect to CS cluster (yellow). Most important borders are those connected with 'makerspace' and 'innovation' (green) cluster with terms such as 'student' or 'learning'. The second important border is with 'person' (blue) cluster with terms such as 'ladder', 'professional' and 'difference'.

(4) (Blue, Person) It is interesting to observe this quite narrow cluster where an important term clearly emerges: 'person' (190 times, 3rd most frequent term). Other terms being closer to the 'action research' cluster (red) such as 'inclusive research', 'disability', and 'life' must also be highlighted because they are all crucial in CoAct's R&I Actions. As we will discuss below, this cluster needs careful attention.

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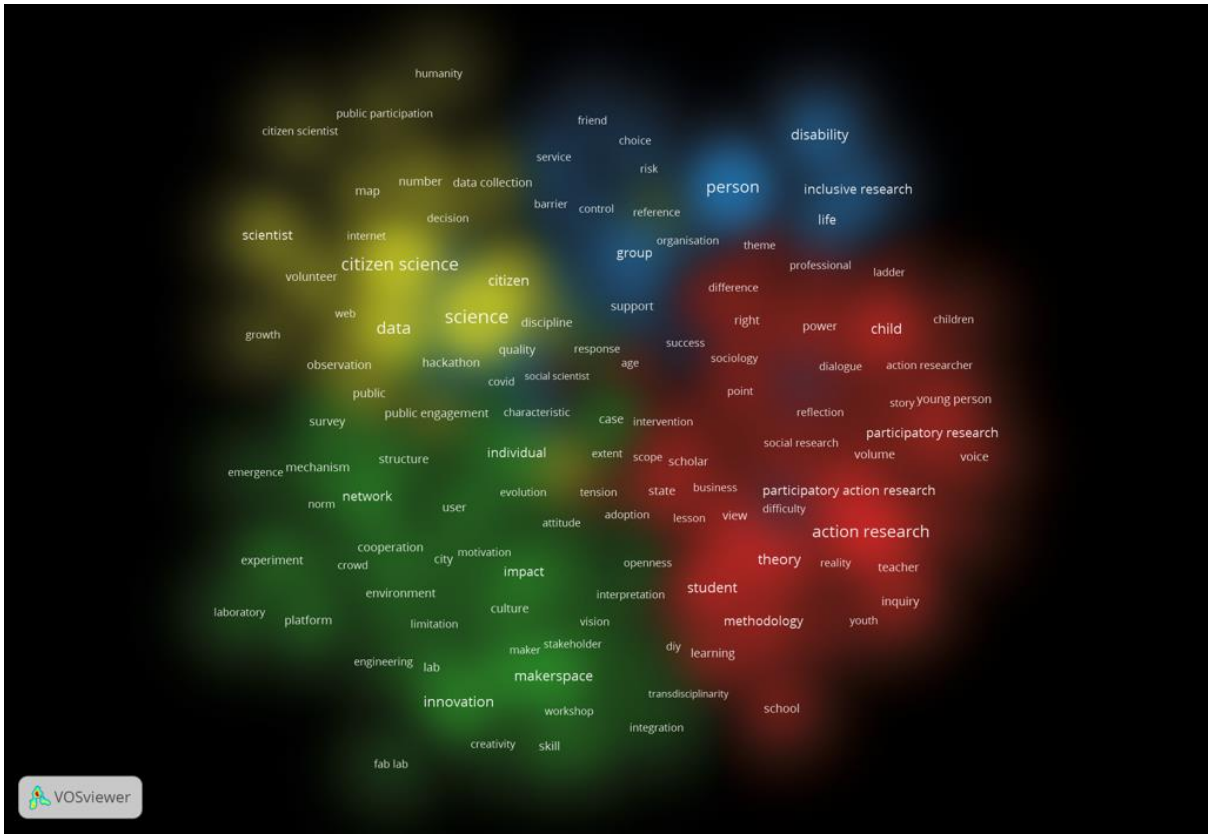

Figure 7: Cluster density visualization with four different clusters 'citizen science' (yellow), 'person' (blue), 'action research' (red), 'makerspace' and 'innovation' (green)

3.3.2. Co-occurrence: Network visualization

In a network visualization, items are represented by their label and by the size of a circle. The size of the label and the circle of an item is determined by the weight of the item which in our case is a specific term. The higher the weight of a term in the dataset, the larger the label and the circle of the item. Lines between terms represent links and in the current case they represent the co-occurrence of a given term among pairs of references. The distance between two terms indicates their relatedness: the closer, the stronger. The strongest co-occurrences links between journals are also represented by lines. It is worth to mention that for some items the label may not be displayed. This

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is done in order to avoid overlapping labels. The colour of an item is determined by the cluster to which the item belongs. Lines between items represent links.

Figure 8 and 9 provides the general landscape already shown in Figure 7 but now enhancing the presence of the different links between the nodes of each cluster. It is interesting to observe and compare the links the following key terms: ’citizen science‘, ’makerspace‘, ’person‘ and ’action research‘. It is important to note that ’person‘ (the third most frequent term in the network) is the only one that it is able to clearly connect with the other three clusters, albeit being the hub of the smallest cluster.

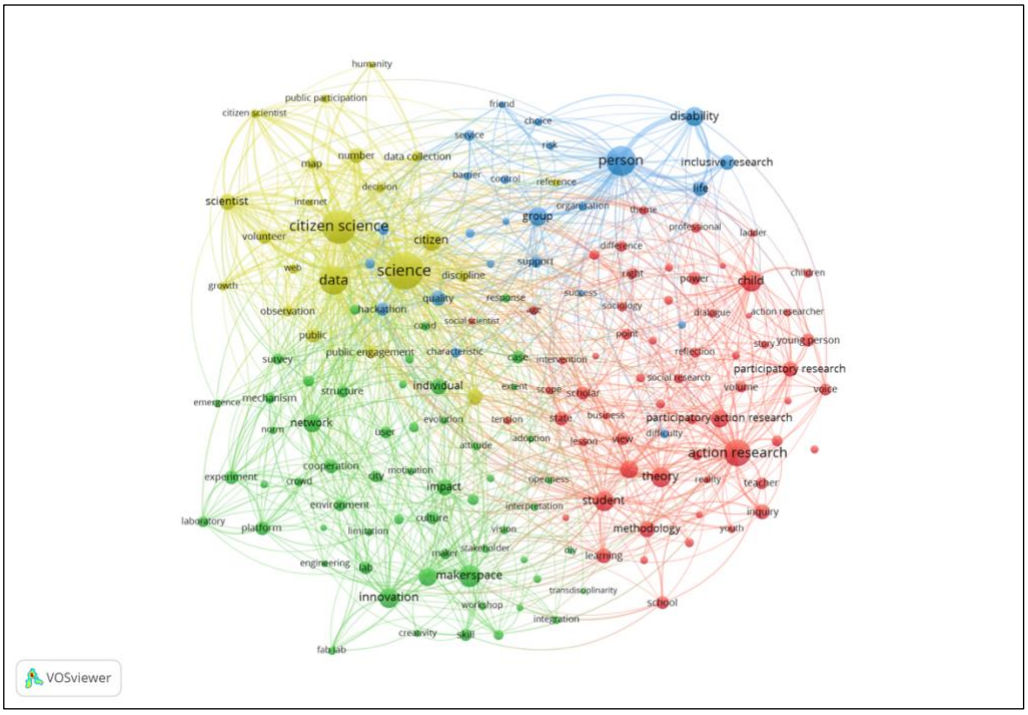

Figure 8: Network visualization: General Figure

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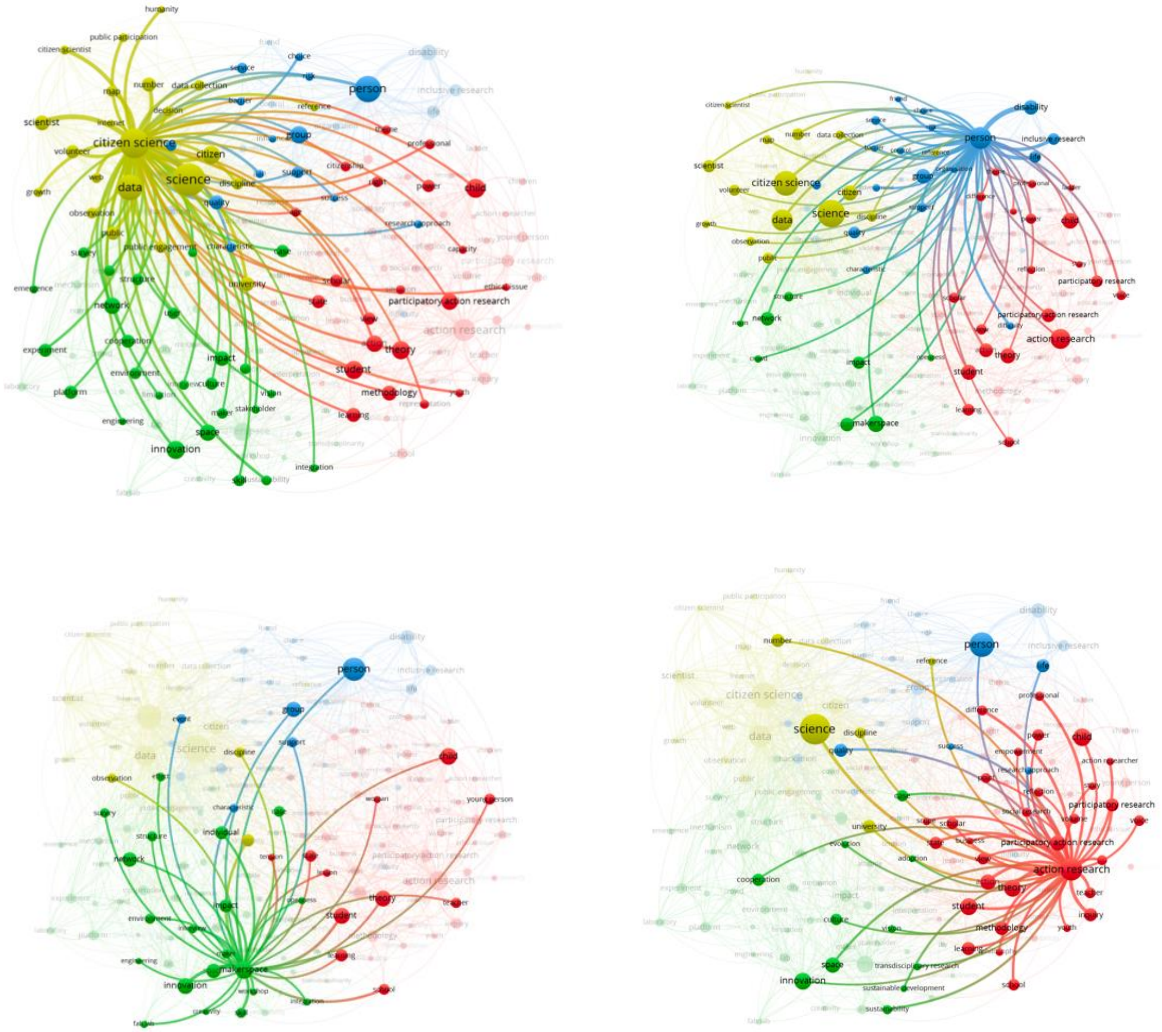

Figure 9: Network visualization: Links emerging from specific terms: 'person', 'citizen science', 'makerspace', 'innovation',and 'action research', and

An alternative to the previous visualization is to colour terms differently, by taking the average among the publication year of all references using the term (see Fig. 10). In this way, it is possible to observe where oldest and newest publications are mostly located. In general, 'makerspace', 'innovation' and 'citizen science' are those with younger publications, thus showing their emerging trend in academic world.

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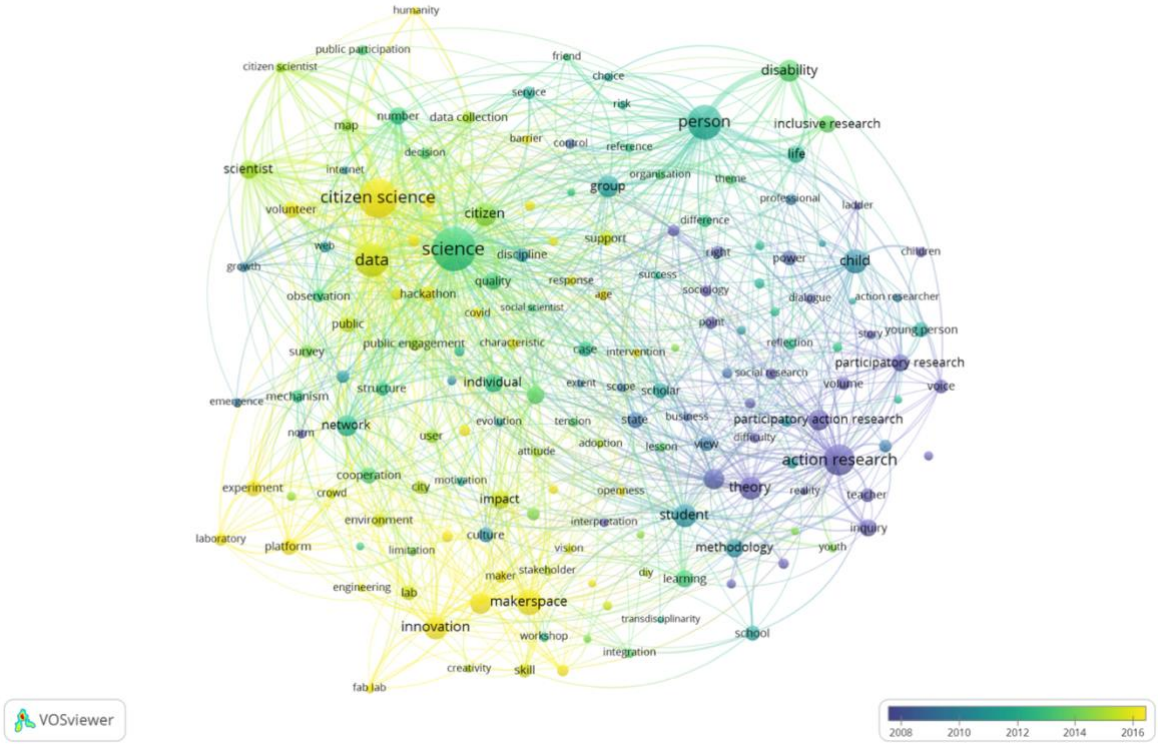

Figure 10: Network visualization: Average publication year of those references using the term by colour

In summary, the analysis in WoS shows that CS is a growing term in academic publications where social sciences and humanities research domains represent about 1/3 of these publications, where multidisciplinary journals appears to be a relevant place to publish the CS research and this could specially relevant to CoAct research outcomes. The term CSS is almost absent in WoS and this has encouraged to focus on the perspectives from CoAct consortium. The bibliographic references being used for current report has helped to observe that despite the diversity inside the consortia the variety of terms being used in titles and abstract of all references is not significantly different to single-authored texts. Commonalities are therefore possible to be identified. Deeper analysis on the shared

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terms through network analysis shows the existence of four main clusters labelled as ´citizen science´, 'action research', 'makerspace', 'innovation' and 'person'. The connections among the shared terms also indicates the importance of the term 'person' which results to be an important hub which connects all clusters, much better than any other hub. This may encourage CoAct to find common ground to the foundations of CSS around the terms belonging to 'person' cluster to favour connectivity among our different backgrounds. Finally, an analysis of the publication years of the references related to each term also shows that younger terms correspond to those related to 'citizen science' while those related to 'action research' cluster appears to be older.

4. Participatory methodologies, methods and approaches

As seen in previous chapters, CSS is still in its infancy and can be considered as an evolving approach, starting to grow in a wide and dynamic frame. CoAct will precisely embrace this diversity, situating CSS at the intersection of many methodologies, methods and approaches. After shortly describing how CoAct is articulated in order to organically embed all these practices (Chap. 4.1), we will analyse them (Chap. 4.1 and 4.2).

4.1. CoAct, a breeding ground for Citizen Social Science

The main goal of CoAct is to demonstrate the scientific relevance and the social impact of CSS in four social and global issues: mental health care, youth employment, environmental justice, and gender equality. For all of CoAct's R&I Actions, the scheme described in Figure 11 is basically followed: working with a citizen group in a vulnerable situation, on a specific concern, and with the support of a local Knowledge Coalition (KC).

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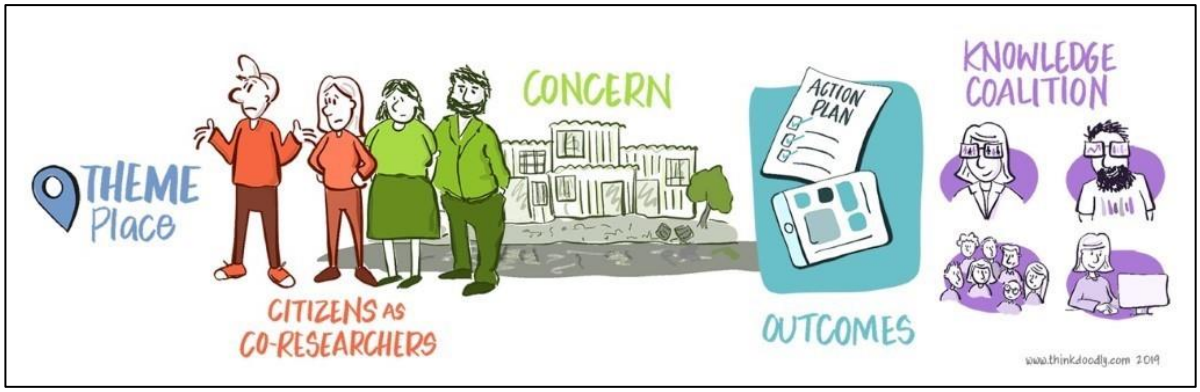

Figure 11: Citizen Social Science put into action in CoAct

Citizens in vulnerable situations are placed at the centre of the research and their role and dedication conceptually recognize them as co-researchers, due to their lived experience in relation to the social concerns that motivate the research. Co-researchers co-create, with academic researchers, the collective research tools (either digital or non-digital) through co-design mechanisms that allow to reach consensus and agreement among participants while including different perspectives and viewpoints. They participate in the research data collection (that may be upscaled to other collectives and individuals) or in some cases do most of the data collection themselves. They analyse and interpret the research results. They are also co-owners of the research data and results.

In parallel, the KC is a more institutional organ of the research devoted to harness Co-Researchers efforts and implement science-related policies and measures. KCs are formed by representatives of public administrations, CSOs, educative organisations and co-researchers. The participation of the individual parties of the KC consist of creating a structural framework for research, participating in the actual research process, or implementing and discussing possible solutions. Regardless of the role, each R&I Action creates a network with the different actors involved and promotes an exchange among them.

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In at least one R&I Action, the Co-Researchers efforts will be expanded to a wider concerned community thanks to digital platforms. By using more standard strategies for participation in CS, this wider community will collect massive data to respond to the co-researchers concerns.

The research will carefully follow CoAct's Ethical Values[3]: inclusiveness, horizontality, equity, trust and respect, Open Science principles, co-ownership and reflexivity. In all cases, the research will be conducted following the five phases described in Figure 12.

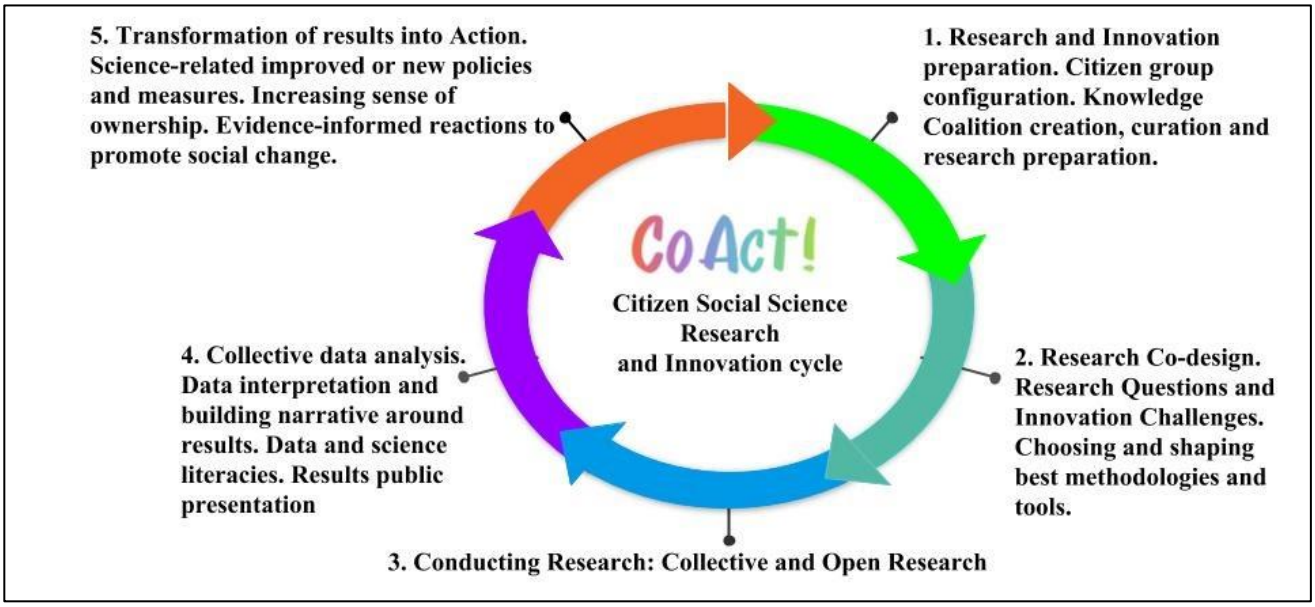

Figure 12: Life cycle for all R&I Actions and Research Pilots in CoAct

By design, CoAct opts to include a wide variety of *methodologies, methods, approaches* and practices that can nurture CSS, as shown in Figure 13 and Table 2. While some of these *methodologies, methods, approaches* can clearly be considered as pillars of an individual R&I Action, others are transversally used.

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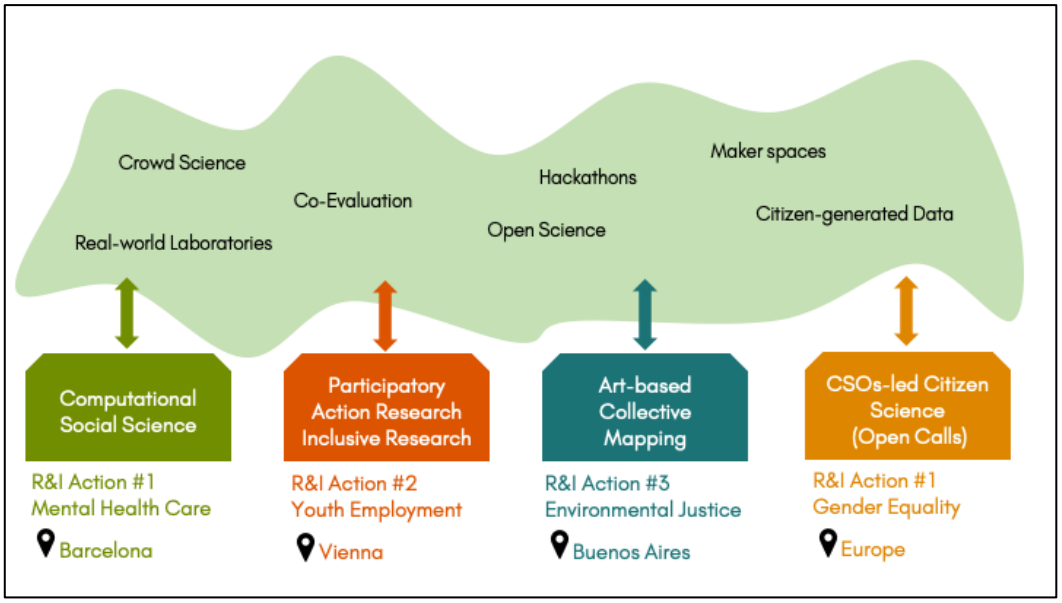

Figure 13: Citizen Social Science methodologies, methods and approaches in CoAct

	R&I Action #1	R&I Action #2	R&I Action #3	Gender Equality
Participatory Action Research				TBD (Open Calls)
Inclusive Research				TBD (Open Calls)
Computational Social Science				TBD (Open Calls)
Real-world Laboratories				TBD (Open Calls)
Art-based Collective Mapping				TBD (Open Calls)
CSOs-led Citizen Science				
Open Science				TBD (Open Calls)
Crowd Science				TBD (Open Calls)
Citizen-generated Data				
Hackathons				TBD (Open Calls
Maker spaces				
Co-evaluation				TBD (Open Calls

Table 2: Mapping of the Citizen Social Science methodologies, methods and approaches used in the CoAct R&I Actions

The following two sub-chapters describe CoAct's R&I Actions pillars and transversal *practices* by detailing their particular historical background, the related scientific fields and topics, their

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epistemologies, their degrees and measures of participation, their social impact, and their potential contribution to CSS methodology as well as the anticipated critical points and blind spots that can make difficult this contribution (for the more details regarding the review methods see Appendix).

4.2. R&I Actions pillars for CoAct

4.2.1. Participatory Action Research

Historical background

Under the label 'Participatory Action Research' (PAR), a vast field of converging approaches is to discover interlinked by a strong commitment to action and participation (Bradbury, 2015; Denzin & Lincoln, 2017; Kemmis, McTaggart & Nixon, 2014; Reason & Bradbury, 2008; Rowell et al., 2017; Whyte, 1990). PAR can be defined as 'a family of proposals and procedures that have a common democratic will, with participation and co-operation between the parties involved, sharing a vision of social transformation' (Thiollent, 2011, 161). People become engaged in action-orientated research to transform local practices by gaining deeper insights and knowledge to envision new forms of a more equal and just society (Rowell et al., 2017).

The methodology of action research goes back to Kurt Lewin (1 who did projects during the 1940s in the USA. Another scholar, William Foote Whyte, stressed the importance of an applied science approach that goes beyond 'discovering basic facts' and that aims at 'linking social research to action' with a special interest in the social organization of companies and farms (1991, 8). Many impulses for further development had come from the global south with a strong commitment to empowering and liberating 'the oppressed' (Openjuru et al., 2015) that fruitfully influenced the more academic discourse in the global north.

The progression and adoption of PAR have gone along with advancements in qualitative research methods ascended with a new thrust in the 1970s as an alternative methodology to positivism and objectivism (Denzin & Lincoln, 2011). The interpretative, cultural, and communicative turn in social

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science lead to a new-born interest especially in the everyday lifeworld, socio-cultural meaning, subjectivity, and identity (Denzin, 1970; Blumer, 1969). Understanding and interpretation of the symbolic layer of human reality came to the fore conceptualized as cultural scripts and social constructions that constitute worldviews and, moreover, guide and explain human actions (Geertz, 1973; Wilson, 1970).

Scientific fields and topics

PAR is a stronghold of collaborative research of academic scientists, practitioners, and laypersons regarding a whole variety of topics. An important area is community, rural and organizational development. Especially for action research projects in rural areas in the global south, a variety of approaches were invented such as Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), and Participatory Learning and Action (PLA) (Chambers, 2008). Another field is Community-Based Participatory Research (CBPR) with an emphasis on working together with members of local communities to make a change in their lifeworld – quite often but not only in public health projects (Arxer & Murphy, 2018; Minkler & Wallerstein, 2008; Nicolaidis & Raymaker, 2015; Wilson, 2018).

Education, educational institutions, learning, and teaching practices are often addressed as Educational Action Research (Feldman, 2017; Noffke & Somekh, 2009). Many *peer-research* projects are concerned with participation of *children* and *youth* so that they can research, envision and transform their lifeworld and to enfold an impact on society (Clark, 2017; Greene & Hogan, 2005; Groundwater-Smith, Dockett & Bottrell, 2015; Thomas, 2000; Thomas, Sauer & Zalewski, 2018; Tisdall, Davies & Gallagher, 2009; Wöhrer et al., 2017).

Another important domain is the everyday life of people, who suffer from *deprived impoverished*, *unequal* and *unjust living conditions* and are commonly *underrepresented* as citizens (Streck & Holiday, 2015). Many projects are located in the marginalized global south or the excluded north with an interest in researching living circumstances and action strategies for improving adversities by inventing new practices for self-determined community organisation (Openjuru et al., 2015). PAR

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projects promote also social justice, gender equity, recognition and diversity (Castillo-Burguete et al., 2015).

Epistemology, methodologies and methods

Not research *about* people, and not research *for* people, but research *with* and *of* people – that is the central claim and epistemological premises of participatory research (Bergold & Thomas 2020, 1). A heterogeneity of epistemic groundings contributes to very different stances and interests in PAR such as pragmatism, phenomenology, social constructionism (Gergen & Gergen, 2008), political and critical theory (Kemmis, McTaggart, & Nixon, 2014), systems thinking (Ison, 2008), humanism, democratization and liberation theory (Wicks et al., 2008). The multitude of epistemologies and methodologies also includes the acknowledgment of the diversity of local and indigenous knowledge systems and worldviews as extra academic epistemologies (Wicks et al., 2008).

To get into an exchange about experiences, insights and knowledge most important, the research teams establish a 'communicative space' in which ideally every voice of every participant is included, can be heard and recognized (Kemmis & McTaggart, 2000). For example, the concept of the 'Research Forum' proposes such a common space of collaborative research and a frame for research activities to organize an exchange of perspectives to deepen social self-understanding (Thomas, Scheller & Schröder, forthcoming).

Degree of and measures for participation

PAR formulates strong claims for deep participation, even if there is the danger of pseudo-participative approaches that only exploit the participants' contributions – partially just because of its growing popularity (Sanfuentes & Garreton, 2018). The people are not so much addressed as 'amateurs', 'the crowd', 'people' or 'citizens' (Mahr et al., 2018, 105) but right away as 'co-researchers' (Bergold & Thomas, 2012). *Deep participation* of the community in the research process has urgent relevance because the people are directly affected by the research outcome. Therefore, they should not only co-create the research process but must also have their say in developing

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evidence-based action plans (Rahman, 2008, 51). The research ideally proceeds in 'a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action' (Lewin, 1946, 38).

This ambition for participation goes along with ethical debates about power relationships, empowerment, political engagement and action potency (Chevalier & Buckles, 2019, 151-154). Ethical reflections are particularly concerned with the researchers' roles in a collaborative research process, especially with power disbalances in the relationship to the co-researchers (Hilsen, 2006).

Social impact and measurements

PAR is a research strategy with strong claims for making a social impact by working together with people in collaborative settings. Collaborative learning for further developing already established social practices is the starting point of most of the PAR projects. The progressive spiral moving upwards in the circle of reflection and action aims at a deeper understanding of the social conditions of everyday life guided by a commitment of the community members for practical transformations towards social progress (Kemmis, McTaggart & Nixon, 2014, 155).

That strong interest in social change by (self-)empowering the co-researchers and their communities through learning and knowledge includes quite often an explicit political dimension. This goes along with the ethical ambition and obligation to overcome unjust und unjustifiable living conditions towards new sense-making and emancipatory practices (Foster & Glass, 2014). Working with communities with deprived and underprivileged backgrounds is regularly connected to political movements even on a larger scale that work against inequality, racism, discrimination and for the proliferation of civil rights and the fight for liberation (Rahman, 2008, 49).

Contribution to a CSS methodology

The obligation to deep participation by establishing communicative spaces for collaborative research provide the chance that both expertise – academic researchers' and co-researchers' – come together

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for a fruitful, inspiring and productive temporary engagement and mutual learning that could lead to new insights and new knowledge productions with a high relevance for action. PAR shares with CS the general ambition of doing applied and transdisciplinary research 'to link practice and ideas in the service of human flourishing' (Reason & Bradbury, 2008, 1). A CSS methodology could learn from PAR particularly the dedication to deep participation by applying concrete steps and instructions for the different stages over all phases of the research process (Thomas & Bergold, 2020). Distinct elements of PAR for elaborating and contributing to a CSS methodological framework are: *First*, a *transdisciplinary approach* for researching already established *social practices* and producing *action-relevant knowledge* (Stokols, 2006; Salīte et al., 2016). *Second*, a strong orientation towards *understanding* and *interpretation* of *socio-cultural* and *subjective meaning* as a supplement to the evidence-based natural science epistemology (Carr, 2006). *Third*, high status of opening up and providing *communicative spaces* that are based on a dialogical approach in which academic researchers and co-researchers participate on equal terms (Kemmis, 2008; Rowell, Riel & Plush, 2017). *Fourth*, a particular emphasis on *research ethics* to reflect on and sensitize for *power disbalances* between academic researchers and co-researchers.

Critical points

Considering PAR as an important part for the different RIA and the further development of a CSS methodology, there are a few critical points to elaborate on in the future. *First*, pathways for stronger convergence of both approaches – CS and PAR – should be developed (Mayer, Kieslinger & Schäfer, 2018). CS promotes Open Science with its fascination to be part of a scientific project with a broad inclusion of people on a mass-scale in a study. PAR is more about researching specific social practices in which practitioners and lay persons are involved very tangible in their everyday lives with a strong call for deep participation at all stages of a research project (Thomas, Scheller & Schröder, forthcoming). *Second*, the focus of PAR to work together with communities and social groups on a micro-social level leads to the question of the relevance and significance of the results can be extended beyond the rather small-scale and single-case research contexts (Gustavsen, 2003). *Third*,

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from the perspective of ethics, there is no easy solution to solve and overcome power disbalances but a necessity for ongoing reflection with practical consequences.

4.2.2.Inclusive Research

Historical background

The Salamanca Statement of the UNESCO in 1994 is often stated as the beginning of the inclusive paradigm in the educational realm (e.g. Cigman, 2010, 159; Bayley, 2018, 181). Challenging strategies of 'integration' (a concept that operates with a majority / norm and a minority that is to be 'included'), the concept of inclusion aims to address all students acknowledging the different challenges and resources of every child (Winzer, 2009; Woolley, 2018). A broad definition of inclusion encompasses 'a rights-based, social justice approach to meeting the needs of *all* within society' (Ekins, 2017, 37) as well as 'shifts from a narrow focus upon the placement and participation of minority groups or individuals to a re-conceptualisation of inclusion as concerned with transforming and restructuring social practices and systems to eradicate all forms of discrimination and inequality.' (Ekins, 2017, 38)

One strand of research that is decidedly committed to inclusion in this sense is 'inclusive research'. The term inclusive research was coined by Walmsley (2001) and Walmsley and Johnson (2003) to describe research together with people with learning difficulties (Nind, 2016, 187). Inclusive research developed alongside and influenced by other action and/or participatory oriented research approaches such as action research, participatory action research, community oriented research and others (Kremsner & Proyer, 2019; Kremsner et al., 2016, 645; Nind, 2014) and shares similarities with concepts that foster the involvement, participation and emancipation of non-scientific people and strive for social change (Nind 2014). According to Nind (2014) inclusive research is nowadays to be understood as an umbrella term. She uses the term deliberately as 'the most generic term (...) to embrace this whole family of approaches, all of which reflect a particular turn towards democratization of the research process' (Nind, 2014, 1).

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Scientific fields and topics

Several scientific fields mainly from the social sciences and humanities follow the approach of inclusive research, especially disability studies (Walmsley, 2004; Nind, 2014). Additionally, although less common, the approach also includes research that is initiated or in collaboration with other groups of co-researchers (e.g. Kremsner et al., 2020). However, *what counts as inclusive research* is not easily defined. While some explicitly position themselves in the tradition of inclusive research (see topics below), others are taken under the umbrella term because lay people are co- or main researchers (e.g. Thomas & O'Kane, 1998; Kellett, 2005 whose research is labelled 'inclusive' by Nind, 2014). The *topics of inclusive research* are as comprehensive as it gets and range from the use of e-devices in research (Cumming et al., 2014), well-being (Haigh et al., 2012; Strnadová et al., 2016) and history (Strnadová et al., 2016), social isolation (Mooney et al., 2019), intimacy (Johnson et al., 2014), disability (Hughes, 2012), living environment and activities (Deguara et al., 2012), injustice and resources (Tilly, 2012); to health (Bell & Mortimer, 2013; Michell, 2012).

Epistemology, methodologies and methods

Inclusive research approaches knowledge production from a social-constructivist perspective (Nind, 2014, 16). Good scientific practice is not characterized by value-neutrality or 'objectivity', but by critically and collectively reflecting on the research process (Kremsner et al., 2016, 647-648; Nind & Vinha, 2012a, 103) and the researcher's situatedness of knowledge (Call-Cummings & Ross, 2019; Koenig et al., 2016, 329). Inclusive research bears relations to more general epistemologies such as the feminist stand-point/sit-point theory (e.g. Harding, 2004), postcolonial theories (e.g. Spivak, 1988) and decolonial theories (e.g. Anzadúa, 1987). The development of inclusive research is influenced by two ideas respectively approaches: First, by the idea of valorisation (Wolfensberger, 1980), meaning that including people with learning difficulties as co-researchers leads to raising their social status (Walmsley et al., 2018, 752; Woelders et al., 2015, 539; Nind, 2014) and secondly, by the principles of emancipatory research, which go beyond participation (in the sense of being included in the process) and question the conditions of social research and knowledge production in general.

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People with disabilities are not considered as advisors, but as initiators of the research process (Walmsley et al., 2018, 753). Simone Aspis highlights the importance of self-advocacy by expressing the - meanwhile famous - slogan 'Nothing About Us Without Us' (Aspis, 2000). It is important to note, that inclusive research is strongly influenced by participatory and emancipatory developments in disability studies that date back to the 80s (Kremsner et al., 2016, 645; Koenig et al., 2016, 321).

Interesting in terms of methodology are the following characteristics of inclusive research described by Nind (2014, 20-31):

- disrupting the hierarchy between researchers and co-researchers;
- maximizing participation and competence by co-researchers;
- enhancing authenticity and insider perspectives;
- empowerment of co-researchers - as individuals and as a group / community;
- accessibility, authorship and readership being by co-researchers;
- acting ethically as a critical issue, connected with accountability, social justice, respect, critical reflexivity.

To achieve these goals, inclusive research draws upon the whole range of qualitative and quantitative methods e.g. group discussions, interviews, autobiography (see for an overview e.g. Nind & Vinha, 2013, 21-27; Cluley, 2017) as well as alternative methods as e.g. photovoice (Cluley, 2017), live drama productions (Nind, 2014, 28), videos (Nind, 2014, 28), or a sonic method (Weinstein, 2019). The crucial point is the adaptation of methods to be used by co-researchers and researchers together to produce scientifically robust knowledge that serves the purpose of the research coalition. How research methods can be adapted is well described for example by the Carlisle People First Research Team Ltd. (2016) which is related to the self-advocacy movement.

Degree of and measures for participation

Participation of lay persons is one of the core ideas of inclusive research. It is perceived as important to strive for including the insiders perspective, to build up competences to enhance participation and

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to aim for accessibility when disseminating research results (Nind, 2014, 20-31) – which can still be improved for example in regard to publications (Strnadová & Walmsley, 2018, 138).

In inclusive research different degrees of participation are mainly understood along a continuum from 'researcher-led' to 'participant-led' (Nind, 2014, 11; Aldridge, 2014, 123) similar to participatory action research projects (e.g. Arnstein, 1969; Hart, 1992). But while Arnstein (1969) and Hart (1992) use the metaphor of a ladder evoking a hierarchy or a 'top' that is to be aimed for, Nind (2014), Aldridge (2014) as well as Hart (2008) in a later publication prefer a continuum. Aldridge (2014) as well as Wöhrer et al. (2017) argue that research projects in fact cannot be attributed to one step on a ladder or one segment in a continuum, but rather combine different degrees of participation according to differing phases of the research project.

Social impact and measurement

Nind (2014, 23) sees an increase of inclusive research over the last few decades. She considers inclusive research as 'inextricably linked with the raise of concerns about people having a voice and making a difference.' Especially in disability studies, but also in women's and gender studies and in post- and decolonial studies, inclusive research resulted out of social movements and protests by 'subjects of research' who felt misrepresented in traditional research (Nind 2014, 18-19). Therefore, inclusive research strives to provide a platform for voices that are usually neither asked nor heard in more established research endeavours. Social impact is an inherent goal of inclusive research, trying to amplify the insights and experiences of marginalised people and use research to influence social and political domains (e.g. Nind, 2014, 8). This goal is also manifested in criteria for doing inclusive research by stating that the research needs to reach communities and should influence the lives of the co-researchers (Nind & Vinha 2012b, 44). One example for inclusive research having an impact on policies and eventually changing them in favour of the people affected is an inclusive study about intimacy of people with disabilities that actually helped to change the law in Australia by setting down

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by law the right for relationships and a sexual live for people with disabilities (Johnson et al., 2013).

Contribution to a CSS methodology

The concept of inclusive research reminds us that academically trained researchers respectively scientists should be sensitive to including co-researchers / citizens from diverse backgrounds in the research process and that research shall be conducted with all of them on an equal footing. Especially persons that are often perceived as vulnerable, excluded, poor, incompetent, etc. and are therefore often not included in participation in otherwise participatory research projects, shall and can be included, if the frame, schedule and design of the research process are adapted accordingly. Inclusive research as stated above contributes to accessible research processes as well as concrete methods that can be used and adapted for other research groups as well.

Another reason why inclusive research can have a great importance for the CSS methodology is an epistemic argument that adds another layer to the political and democratic motivations for including marginalized people as co-researchers (Arztmann et al., 2016, 80). Including marginalized people - who have been historically excluded from scientific knowledge production and considered as incapable of contributing to scientific projects - in inclusive research processes opens up space for new forms of insights, reflections and challenges which have the potential to change (social) science as a whole.

Critical points

Inclusive research has a lot to offer, however critique to several aspects of inclusive research has been discussed. Much of this criticism concerns issues relevant for different types of participatory research and is therefore especially interesting for CSS: According to Ekins (2017, 43), the concept of inclusion has become a diffuse term over the years. Some research projects claim to be inclusive, but rather use the label as a romanticized and de-contextualized catchword or to mask tokenism (Cahill, 2007, 299), instead of applying core aspects such as participation, reflection and transformation (Koenig,

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2016, 327; Nind, 2014, 73). The value of inclusive research is the inclusion of multiple perspectives. Research quality is determined by the critical analysis of accounts rather than assuming a 'purity of voice and perspective' (Nind, 2014, 68-70).

Another critique refers to the tendency towards normalization, especially in the educational realm. The lens of normalization measures co-researchers by normative standards instead of promoting diversity, considering the individuality (vgl. Bayley, 2016, 183-184) or considering the disempowering effects of this approach (Woelders et al., 2015; Artzmann et al., 2016). Inclusive research opens up new ethical complexities, opposing the widespread idea of it being more ethical (Nind, 2014, 72). Challenges in regard of integrating different abilities (e.g. Carlisle People First Research Team Ltd, 2016; Woelders et al., 2015), informed consent and data processing procedures (Aldridge, 2014, 121; Kremsner et al., 2016, 647-645; Locke et al., 2013, 109-110) can be part of the research process. Although inclusive research claims to involve the unheard and unseen, some individuals are more easily recruited into the research endeavours due to their resources and motivation than others (Nind, 2014, 76). Kremsner et al. (2016, 648) urge to consider those individuals whose voices are still not heard and who face multiple forms of oppression (Nind, 2014, 77).

4.2.3. Computational Social Science

Historical background

Computational Social Science (CompSS) refers to a research field concerned with computational approaches applied to model, simulate, and analyse social phenomena (Lazer et al., 2009). The rapid spread of social media, smartphones, and other digital tools and platforms enables us to collect and process data about human behaviour on a scale that was unimaginable before. The digital revolution is challenging the way social scientists observe behaviour, ask questions, run experiments, and engage in mass collaborations (Salganik, 2019). CompSS is thus aiming to provide new approaches to core questions about social behaviour in a digital world which has in turn altered the frequency, range and style of human interactions (Conte et al., 2012).

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During the 1960s, social scientists began using computers for conducting statistical data analysis in different contexts, such as financial markets or human mobility. Almost parallel to the internet 2.0 the term 'Computational Social Science' was coined (Lazer et al., 2009) and the 'Manifesto of Computational Social Science' was published (Conte et al., 2012). CompSS is currently organized in an internationally distributed and active community of researchers with very different backgrounds. A robust network of associations, universities, research institutions has already been established, which holds specific positions and organise national and world. With the 'Journal of Computational Social Science' the community has established at least one dedicated interdisciplinary peer-reviewed medium and there are many others that are keen to receive contributions following this kind of approach, e.g. Proceedings of the National Academy of Science, Science Advances, Nature Communications, Nature Human Behaviour, Scientific Reports, Plos ONE, EPJ Data Science.

Scientific fields and topics

CompSS is transdisciplinary in nature, lying at the intersection of computer science, statistics, complex systems sciences, statistical physics, behavioural sciences, urban planning, epidemiology, environmental health, linguistics, archaeology, media studies and the social sciences in its broadest sense. It is grounded in the principles of Complex Systems Science emphasizing the multi-scale and self-organised natures of social phenomena (Newman, 2003), which emerges from interactions among data collections of individuals through changing and dynamic networks of variables (Watts, 2013; Conte et al., 2012; Lazer et al., 2009).

CompSS has been applied to study a wide range of complex social phenomena: from spatial segregation patterns (Vincović & Kirman, 2006) to effects of social stressors on political instability (Cioffi-Revilla & Rouleau, 2010), from the dynamics of epidemics (Balcan et al., 2009), to group formation (Backstrom et al., 2006), social organization (Axtell et al., 2002) and social movements (Tremayne, 2014), from emergence of human altruism (Nowak & Sigmund, 1998) and cooperation (Cigarini et al. 2020; Vicens et al. 2018a; Santos and Pacheco 2005) to information propagation (Karsai

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et al., 2011; Onnela et al., 2007) and the structure of friendship networks (Ugander et al. 2011; Tamarit et al., 2018), among many others.

Epistemology, methodologies and methods

CompSS can be considered a quantitative data-driven science that also builds mathematical models to provide further insight in the phenomena observed. It derives hypotheses by discovering patterns in vast amounts of data, rather than relying all possible interpretation on theory (Conte et al., 2012; Lazer et al., 2009). In this sense, special and very particular nuances are not the core of the research endeavour although diversity and heterogeneities among individuals are carefully considered. They are one of the differential traits of CompSS with respect standard statistics in the field of social sciences. The formal proof of the mathematics of algorithms is another trait what distinguishes CompSS epistemically from other quantitative social sciences (Bankes et al., 2002). More specifically, knowledge in CompSS is constructed through predictive and explanatory (mostly computational) modelling. Formal models are used to identify generalizable (and as simple as possible) mechanisms or rules that give rise to non-predefined (thus emergent) properties of social systems. Mechanisms and rules are sometimes playing with feedback on individual decision-making and behaviour (Bankes et al., 2002).

Research in CompSS exploits digital data provided by digital technologies. One example is how mobility studies have increased their potential by considering mobile phone data (González et al., 2008), Twitter posting geolocation (Llorente et al., 2015) or RFID or Bluetooth contact sensors (Cattuto et al., 2010) in the research. Instant messaging and social networking sites (Ugander et al., 2011), email (Kossinets and Watts 2006), Twitter contents (Tremayne, 2014) or online blog content (Backstrom et al., 2006) also could bring relevant information and knowledge being much more focussed on social interactions. Other options are to run randomized laboratory experiments (Rand & Nowak, 2013) or massive lab-in-the-field experiments (Gracia-Lázaro et al., 2012). Most common data analysis and data-driven mathematical modelling take random process, stochastic dynamics, and

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networks while more recently deep learning and machine learning techniques are incorporated. These data is analysed through the application of specific quantitative computational methods (e.g. Cigarini et al. 2020; Vicens et al. 2018a; Rand & Nowak, 2013), social network analysis and other related approaches that explores synchronization and correlations (Ugander et al., 2011; Kossinets & Watts, 2006), and geographic information system (GIS) analysis (Llorente et al., 2015). Finally, most recent models are data-driven are starting to explore the potential of machine learning and Artificial Intelligence to find best algorithmic expressions to describe phenomena (Reichardt et al., 2020).

Degree of and measures for participation

In experimental CompSS research, the depth and scale of participant samples, in the order of magnitude of tens of thousands in the case of digital data collection (Ugander et al., 2011; Kossinets & Watts, 2006), and even exceeds in number 'crowdsourced'-type participation in CS (Haklay, 2013). The level of participant's engagement is almost restricted to the data collection process and in most of the cases this is done in a passive manner. Indeed, participants are often unaware that their data is being collected and processed from online digital technologies related for instance to Twitter or Facebook, which raises ethical issues about informed consent procedures and risks of harm (Kraut et al., 2004). Alternatively, with more laboratory experiments are typically conducted within universities or clinical settings with restricted populations of participants, often university students, challenging the generalizability of the findings to non-students populations and non-conventional cultural settings (Henrich et al., 2010). Virtual online laboratories are also a widely extended approach that aims to overcome this limitation recruiting subjects worldwide. The researchers use different kinds of software (e.g. Chen et al., 2014) in platforms such as 'Amazon Mechanical Turk' (Mason & Suri, 2012). Participants are most often paid for their time and contribution, stressing the tension between volunteer and paid participation already questioned in discussions about CS (Weber et al., 2019) and still raising challenges regarding the representability of the samples (Goodman et al., 2013).

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Despite CompSS is already engaging the public as subjects in their research, research projects that experiment with the idea of CSS are hard to find. Very few virtual labs (Radford et al., 2016) or lab-in-the-field settings (Vicens et al., 2018b) enable participation of volunteers with no monetary incentive. Other experiments are related to human mobility (Gutiérrez-Roig, 2016) and social interactions (Cattuto et al., 2010) where tracking is done in a predefined area and in a fully conscious manner by each of the volunteers. Participants are indeed rarely included in research design and planning, with only a few exceptions (Cigarini et al., 2020; Bonhoure et al., 2019; Vicens et al., 2018b). In the latter cases, participants chose and agreed as a group on the research topic, codesigned the details of the public and collective experiment, and interpret data while internally discussing actions to respond to the initial shared concern with the research outcomes (Senabre et al., 2018; Sagarra et al. 2012; Perelló et al., 2014).

Social impact and measurement

The social impact as discussed in CompSS papers is mostly connected to the practical use of the results produced by policy makers for evidence-based policy (Conte et al., 2012). The design of models that capture aspects of the structure and behaviour of the social phenomena under study has been emphasized (Watts, 2013; Conte et al., 2012; Lazer et al., 2009; Bankes et al., 2002). This, in turn, is often supported by arguments over the scale and depth of the data generated (Ugander et al., 2011; Kossinets & Watts, 2006) and the ability to represent complex social phenomena with mathematical modelling behaviour similar to that of the social system under study are typically used to suggest the promise of this approach (Bankes et al., 2002).

The recent COVID-19 pandemic crisis management. Concepts such as ‘social distancing’ or ‘flattening the curve’, are perfect examples on how this field can actively and quickly contribute to actionable insights in the context of policy making. Models and sophisticated projections developed by CompSS are actually being used to stablish measures to control pandemic and they are dominating part of the public discussion (Arenas et al., 2020; Vespignani et al., 2020; Kraemer et al. 2020; Mazzoli et al.,

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2020). Some of the reputed experts in this field are assessing British, Spanish or Italian public health agencies and they are behind the disease monitoring (Mitjà et al., 2020). Easy-to-understand simple concepts and data visualizations are sent to understand how the spread looks like, or when epidemics would peak and when there could be a new outbreak. Some of the researchers are also behind contact tracing monitoring being planned by several countries. While others are assessing the risk of infodemics in social media when responding to COVID-19 epidemics (Gallotti et al., 2020).

Finally, open access and open source are widely used practice. Some researchers however still reclaim to extend and intensify this practice in fields such as behavioural sciences in order to increase replicability (Camerer et al., 2018). The results in CompSS are further argued as bridging the science-society gap by enabling citizens to evaluate different policy options in the light of their personal needs and goals (Conte et al., 2012). Nevertheless, defined indicators for assessing and evaluating short- and long-term social impact of CompSS research are not covered, and there is little evidence on the experience of engagement from participants' perspectives.

Contribution to a CSS methodology

Useful for expanding a CSS methodology is especially the representational aspect of CompSS research, namely the scale and complexity of its explanatory power (Bankes et al., 2002) that allows to capture and model important phenomena, and to bridge the science-society gap by facilitating the citizens understanding of science and important phenomena, thus enhancing citizens participation in the decision process (Conte et al., 2012). It has been shown that visualizing a phenomenon has more power than just telling people what the numbers are, and thus models and representations are techniques that affect public understanding (Spiegelhalter et al., 2011; (Michels & de Graaf, 2010).

CompSS is also transdisciplinary in nature, and, as already suggested, research design strategies are to reflect the multiperspectivity of stakeholders to create a deliberative space for mutual learning and change (Sagarra et al., 2016). CompSS can in this way better Beyond the provision of new tools and methods, CompSS and especially the complex system approach, may be a crucial lever towards

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blurring the dividing lines among disciplines that CSS puts forward, and creating a truly transdisciplinary non-compartmental knowledge to address important social problems (Conte et al., 2012). The intensification of participation within CSS can therefore on one way provide more and better data in the sense that can better capture and respond to citizens' concerns.

Critical points

Critical in CompSS is, however, the restricted degree of citizens engagement. The top-down structure of CompSS limits citizens participation to the (sometimes uninformed) data collection process (Kraut, 2004). This way, the potential of CompSS for increased public understanding and enhanced citizen interaction with decision-making is questioned, and ethical issues are raised. It has been suggested that it is more co-created forms of citizen scientists interaction that may hold the greater public understanding potential (Bonney et al., 2015). Increasing the quality of public engagement, namely participation and scientific empowerment, may also increase the quality of the data and the research itself (Sagarra et al., 2016; Shirk et al., 2012).

Challenging in CompSS is also the lack of complementary applications of multiple research traditions, including social sciences debates and qualitative approaches to understand social phenomena, an effort which could help to engage seriously with transdisciplinary dialogues (Watts, 2013; Conte et al., 2012). Any problem remains difficult or intractable to solve only through formal modelling (Bankes et al., 2002).

Perhaps the biggest challenge is on the data side, with respect to ethics and privacy (Vayena & Tasioulas, 2015) and in turn democracy as already discussed by some authors of the field (Helbing et al., 2019). The requirements for distributed monitoring, permission seeking, and encryption of human data indeed poses challenges (Zuboff, 2019). Related to concerns over identity breaches is the risk of harm to participants, particularly greater when dealing with more sensitive data (Kraut, 2004). A more transparent and accountable management of data generated and analysed in CompSS research is

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thus crucial, both with respect to the governance of the data itself, and also its end uses (see very recent paper on Covid-19 and citizen's control on data (Nanni et al., 2020).

4.2.4. Real-world Laboratories

Historical Background

Real-world Laboratories (RwLs) have become a popular social experimentation approach at the intersection between science and society, especially in the field of sustainability and transformative studies (Schäpke et al., 2018a; 2018b). Originating in 'participatory design' (Schuler & Namioka, 1993; Kensing & Bloomberg, 1998) and technology studies, the first 'living labs' were open-innovation ecosystems for user-centred technology development at the Massachusetts Institute of Technology (MIT) (Pallot et al., 2010). The object was to involve end-users in the knowledge and technology production to find workable solutions for practical contexts (Callon & Rabeharisoa, 2003). In contrast to these private-public-partnerships between companies and universities in 'living labs' (Niitamo et al., 2006) RwLs are initiated in an academic context and financed by state research funds (Wagner & Miller, 2018; Defila & Di Gulio, 2018). The main feature of RwLs are controlled experiments to conduct research on social innovations around various social concerns. New ideas, products, services, processes, systems, scenarios are tested, examined, evaluated in real-world contexts (Menny, Palgan & McCormick, 2018). For expanding our CSS methodology in this paper beyond RwLs, we focus also included similar social experimental approaches like 'urban transformation labs' (Engels & Walz, 2018), 'labs in the field' (Gneezy & Imas, 2017) and 'citizen social labs' (Vicens et al., 2018b).

Scientific fields and topics

RwLs are utilized in heterogeneous scientific fields with the aim of testing transformative impacts on society. The majority of the papers in our review belong to sustainability sciences combined with a focus on urban planning (Engels & Walz, 2018; Heiskanen et al., 2018; Menny, Palgan & McCormick, 2018; Leminen, Rajahonka & Westerlund 2017) and educational learning (Singer-Brodowski, Beercroft & Parodi, 2018). For example, in the 'Urban Transition Lab 131', citizens have been

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experimenting with new forms of mobility, energy concepts, social issues in urban space and sustainable consumption (Singer-Brodowski, Beercroft & Parodi, 2018, 24). Besides methodological reflections there is a number of conceptual papers addressing potentials of RwLs towards social transformations (Schäpke et al., 2018a; Leminen et al., 2017, Renn, 2018), the research design of RwLs (Parodi et al., 2018), tensions in RwLs between different stakeholders (Engels & Rogge, 2018). Two papers contribute to 'behavioural science' following a lab-in-the-field approach looking at economical behaviour (Gneezy & Imas, 2017) and social collaboration (Vicens et al., 2018).

Epistemology, methodologies and methods

RwLs in general are experimental research spaces planed mostly top-down by a university or a research institute to examine systematic interventions in the social life–known as the 'experimental turn' in sustainability science (Schäpke et al., 2018a). Against this academic background, RwLs are epistemological embedded in discourses about research and innovation and potentials for social impact towards sustainability, transdisciplinarity and transformative science (Engels & Walz, 2018; Engels & Rogge, 2018; Schäpke et al., 2018a). Researchers refer to various theories depending on the focus of the paper, i.e. 'structuration theory' (Giddens, 1984), 'theories of change and realistic evaluation' (Blamey & Mackenzie, 2016), 'participation and urban governance' (Arnstein, 1969), and 'computational social science' (Lazer et al., 2009). However, the discourses about RwLs appear rather disconnected from the debate on CS. Direct links and references in the epistemic and methodological discussion are the exception (Vicens et al., 2018b).

Besides the experimentation approach, a wide variety of qualitative and also quantitative methods are applied in RwLs especially as methodical extensions ranging from interviews, expert forums, focus groups, workshops, dilemma games, walks, artistic installations and public discussions on the one hand, to surveys with standardized questionnaires, on the other hand. Most of the times, the aim is to conduct highly contextual local data in order to upscale or transfer the results within a progressive spiral of knowledge in different contexts (Renn, 2018).

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For example, Vicens et al. (2018) set up an experiment in a public space in Barcelona, where citizens worked through a set of social behavioural dilemma games installed on tablets. In a different way, Heiskanen et al. (2018) worked with citizens in their homes in eight European countries by involving them in social experiments by applying a gamification approach in order to disrupt their everyday practices and reduce CO_2 emissions.

Degree of and measures for participation

Academic researchers usually initiate the RwLs whereas the collaboration is focused on experts from public institutions, public agencies, municipalities or businesses but less often on civil society groups. Such research consortiums define the thematical foci and the social topics that are object of the RwLs. Albeit, these experts are included in the co-design of the research, most of the times, citizens are not involved but only come into play in the experimentation phase as data providers. Higher potentials for participation and co-creation are rarely discussed explicitly. From the point of view of a CSS methodology, there is a need for more participatory research design strategies within this methodology.

We found two different concepts of participation in RwLs: The *first* type of participation refers to the different parts of the research process. The vast majority of RwLs applies only contributory or at least collaborative forms of participation of citizens. Citizens are just referred to as ‘volunteers‘ or ‘participants‘ and not in a stronger sense as ‘co-researchers in the literature, what is critically connotated as ‘lab rats’ (Leminen, Rajaonka & Westerlund, 2018) whose contextual knowledge is ‘exploited’ in the experimental context (Engels & Rogge, 2018).

The *second* type of participation describes an outreach approach. In contrast to a ‘traditional’ experimental lab setting behind closed doors of research facilities, experiments in the ‘social real world’ open up participation possibilities for a wider public audience, especially if carried out in public spaces (Vicens et al., 2018). Those papers which discuss the issue of participation explicitly, emphasize the emancipatory potentials (Schäpke et al., 2018b) and transformative capacities (Menny, Palgan &

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McCormick, 2018) that the integration of co-researchers in the conceptualization, conduction and evaluation of RwLs could provide (Parodi et al., 2018).

Social impact and measurement

Social impact is the determining objective in RwLs as a combination of evidence production and sustainable solutions to societal challenges. There are two types of social impact discussed in the papers. *First*, initiating a certain impact with the produced practical knowledge is linked to a strong emphasize of dissemination results especially into the political system as a substantial contribution to sustainable development. Yet, participation of citizens seems to play a less important role in the discussion about social impact in RwLs. Nonetheless, some papers also emphasize the effects of co-creational experiences by the participants during the participation in the experiments by opening up a space to develop and discuss new ideas. Here transformative potentials are linked to higher levels of acceptance of transformative practices that come with higher levels involvement of citizens, for example in a project conducted in Hamburg dealing with future urban development or for introducing LED light technology for pedestrian pathways (Menny, Palgan & McCormick, 2018).

Second, *participants satisfaction* for science is another type of social impact that focusses on the positive experiences during the participation in the research. Thus, bringing science to a broader audience outside of a conventional lab environment could contribute to an increased openness for science in general and CSS in particular (Vicens et al., 2018b).

Nevertheless, defined indicators for assessing and evaluating (short-term/long-term) social impact seem underdeveloped, even though the ambitions towards a conceptual integration of a ‘theory of change’ combined with ‘realistic evaluation‘ in RwLs marks another step towards a comprehensive impact measurement (Heiskanen et al., 2018; Menny, Palgan & McCormick, 2018).

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Contribution to a CSS methodology

Useful for expanding a CSS methodology is especially the *interventionist* character of social experiments to initiate debates and reflection among the citizenry. Furthermore, RwLs conducted as a CSS project could provide both evidence-based and socially robust knowledge that aims for social impact on various scales–from pioneering with changed daily life practices at home up to recommendations for policymakers on a transnational level. Research design strategies need to reflect a given *multi-perspectivity of stakeholders* in order to provide a deliberative space for mutual learning and change (Engels & Walz, 2018). An *awareness of tensions* between diverse interest groups seems necessary for securing broader generalizability and transferability of results (Engels & Rogge, 2018). A conceptual sensitivity for *structural dimensions* while setting up a RwL allows to reflect the underlying interpretative schemes, norms, allocative resources and authoritative resources in the research setting (Schneidewind et al., 2018). Moreover, the implementation of 'theories of change and realistic evaluation' (Heiskanen et al., 2018) could become valuable for conceptualizing a CSS methodology. The interplay between evidence-based data, social impact and citizen participation could be amplified by integrating RwLs into a CSS methodology. The transdisciplinary approach in RwLs creates a research environment with a high potential for expanding participation and co-design around citizen concerns (Parodi et al., 2018). Broadening participation in social experiments could contribute to increase 'real world' applicability of results and cross-context relevance (Gneezy & Imas, 2017; Vicens et al., 2018b).

Critical points

Three critical points of the RwL methodology would need attention regarding an adoption within a CSS methodology: *(1) Hierarchies and participation:* The top-down structure of experimental research settings restricts participation. An explicit conceptualization of participation and integration of citizens in all phases of research would help to build and maintain trustful relations between the different stakeholders working together co-create research over a certain time in the labs (Engels & Walz, 2018). *(2) Experimental setting*: The research strategy that derives from a positivistic

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methodology of controlled experiments reduces the potential of co-creation. Here, a CSS methodology could turn 'experimental testing arenas' into 'co-created experimental spaces', where citizens' perspectives and interests could play a more important role for transformative practices. *(3) Measurements of impact:* Indicators for measuring outcome are missing in almost all papers, even though social impact and change for sustainability are generally seen as key factors of RwLs. Against this background, the consideration of a CSS methodology could integrate co-evaluation and impact measurements from the beginning.

4.2.5.Art-based collective mapping

Historical background

This review focuses on art-based collective mapping techniques that combine graphic tools and collaborative efforts in order to create counter-hegemonic cartographies to communicate situations of injustice, particularly in the Latin-American context. It has been used as a political tool for resistance and transformation. As a research practice it is related to the arts-based paradigm, an umbrella term including various methodologies that apply some form of artistic practice in order to improve reflexivity through the research cycle, originated in the US and Europe (Leavy, 2015; Wang, et al., 2017). It has also been nurtured more directly by Latin-American Participatory Action Research (Fals Borda, 1987) used particularly in education (Freire, 2000; Illich, 1971) and critical geography (Santos, 1978). In terms of academic research methods, collective mapping is related to participatory cartographies, mainly used in sociology, geography and anthropology. Such method does not use art-based techniques but draws intensively from participatory action research (Sanderson et al., 2010).

The historical background of the art-based collective mapping can be traced back to the political effervescence, social mobilization and class struggle in Latin America during the 1960s and 1970s. This was later revisited in the context of anti-globalisation and human rights movements in the 1990s. It was then when distinction between arts and politics blurred, creating what was called 'artistic activism' (Longoni, 2018). Similarly, the emergence of the art-based paradigm was also aligned to

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social justice movements in the northern hemisphere in the 1970s and also consolidated in the 1990s (Finley, 2008; Leavy, 2015; Wang et al., 2017). In the 2000s, there was an increasing interest in participatory mapping processes with the advent of technological tools that allow people to more easily intervene cartographies using GIS (Boschmann & Cubbon, 2014; Sieber, 2006). These contributed to the emergence of counter hegemonic mapping practices known as 'crowd mapping' (Dodge & Kitchin, 2013; Mattioli, 2014; Nêto, 2015). They created a new ethos for activism and community (Milan, 2016).

Scientific fields and topics

The art-based collective mapping methodology has been predominantly used as a tool of political activism. The socio-environmental problems that were addressed are related to environmental justice, popular education and human rights (see several non-academic productions by Iconoclasistas, 2016). In order to refer to scientific fields and to quote academic literature we expand our focus to participatory cartographic methods (i.e. participatory methods using maps).

In Latin-America there are studies from different disciplines, such as critical geography working on socio-environmental conflicts (Mora Calderón & González Hernández, 2019) social work studies on impoverishment (Rosso & Escurra, 2019); urban studies on urban planning and indigenous communities (Olivares Díaz & Escutia Molina, 2019) and on local policy making (Tapia-McClung, 2016); anthropology on ancestral appreciations of the territory (Álvarez Ávila & Palladino, 2019). In Europe and the United States participatory cartographic methods have been used also in development studies (Sanderson et al., 2010) and urban planning (Wridt, 2010) using GIS.

Epistemology, methodologies and methods

From an epistemological point of view art-based collective mapping belongs to participatory action research (Fals Borda, 1987; Sanderson et al., 2010). As mentioned above, although there is no explicit connection in the literature using art-based collective mapping, we could trace bridges to the arts-based research methods (Leavy, 2015a). These practices include the display of visual images that

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allow to reflect creatively and express in a non-verbal manner different levels of the experience and facilitating “empathic understanding” (McKinnon, 2011; Wang et al., 2017).

As for methods *workshops* are the most common qualitative method for data collection. They incorporate an instance of 'sharing' that exposes group stories, revealing differences and creating horizons for both approaching problems or for political action (Iconoclasistas, 2016; Mora Calderón & González Hernández, 2019; Olivares Díaz & Escutia Molina, 2019). Iconoclasistas also use *methods from graphic design*: iconographic art and other visual resources to add a symbolic dimension to the collective results to encourage greater exchange and to stimulate creative work. These visual resources simplify the subsequent systematization of information (Iconoclasistas, 2016; Iconoclasistas & Ares, 2018).

In participatory GIS field (Sieber, 2006) the use of collective mapping methodologies is applied in some cases for the development of sketch maps in processes that aim at involving local communities in policy and decision making, integrating local knowledge data collection with map production (Boschmann & Cubbon, 2014). In some cases, the researchers conduct individual interviews and work with maps as a graphic elicitation mechanism to access to the participants’ contributions, later compiled in a composite map. Others involve group workshops (Weiner & Harris, 2003; Wridt, 2010). Wridt (2010) defined community mapping to the process in which small groups of five people used aerial photographs to discuss and map themes of interest, using coloured markers and stickers. Weiner & Harris (2003) worked with local groups to include their differentiated knowledge through the intervention of GIS generated topographic maps with tracing paper, and coloured pencil and markers.

Other research methods used to obtain information are *citizen-driven data collection*, either through *door-to-door* surveys or censuses organised by neighbours as in the ‘Ituzaingó case‘ (Sannazzaro, 2016), when a group of citizens managed to map several health problems of their community that were related to the use of agrochemicals in fields near their homes.

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And the last method that can be pointed out is the use of online *platforms* that allow participants self-reporting on agreed issues. There are several experiences related to political activism using platforms to create citizen-driven data (Fressoli, Arza, & del Castillo, 2016).

Degree of and measures for participation

Workshops are organised differently when used for social research or for activism. Following Golumbic (2015), workshops in former case could be characterized as 'collaborative' practices. Researchers initiate the process as part of their own agenda involving the community members as active participants. In practice, this means that they are not merely data providers, but rather their opinions are considered and are engaged in the collective analysis of the workshop's results (Mora Calderón & González Hernández, 2018; Olivares Díaz & Escutia Molina, 2018; Rosso, Inés & Escurra, 2019).

In contrast, workshops held in the context of political activism mostly involve radical 'co-creative' practices (Golumbic, 2015), since citizens' groups follow their own agenda. They are the ones who initiate the process by contacting "facilitators" (i.e. the usual expert roles fulfilled by researchers is not occupied here). From start to end, every step is discussed, like who should participate, what topics should be discussed, etc. This is usually done through interviews, meetings and reports discussed during workshops and subject to modifications. In the final stage, results are shared, and conclusions are collectively constructed, with citizens and communities keeping the created material and the know-how about collective mapping techniques (Braceras, 2012; Iconoclasistas, 2016). Citizen-driven data practices usually provide measures of the specific degree of participation (e.g. amount of data downloaded or created) but the degree of commitment of participants varies across initiatives widely differ (Fressoli & Arza, 2016).

Social impact and measures

The benefits associated to collective mapping methodologies are threefold. Firstly, they create a common vision about specific phenomena, which sometimes implies to transform the collective

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subjectivity (Iconoclasistas et al., 2016; Lafuente & Horrillo, 2017). Secondly, these exchanges often create long-standing collectives that act together on shared causes (Bossi & Grupo de Arte Callejero, 2009). Thirdly, they could also promote long-term social change (Rosso & Escurra, 2019; Tapia-McClung, 2016).

Maps and other information gathered during workshops are owned by the community and serve as an input for demanding public policies or other actions the community might find useful. Collapsible cartography and other resources can usually be downloaded and/or both analogically or digitally shared and thus become a tool for political communication. They could promote other forms of subsequent participation such as crowdsourcing of data and engagement in ongoing public policies processes. Some of them may become artistic pieces that circulate widely in other circles beyond those originally produced, creating new opportunities to engage with and support communities' struggles (Longoni, 2018).

Since collective mapping is mostly used in activism there is no academic study systematically assessing impact, but rather anecdotal evidence of how these resources have been used for social change. For example, one cartography created by Iconoclasistas in 2013, República de los Cirujas, was used by the community as proof of their neglected activity when negotiating with different local authorities in José León Suárez (Buenos Aires) (Arza et al., 2016). In the 'Ituzaingó case' the maps were used to promote regulatory changes regarding the use of agrochemicals, which became effective at local level (Sannazzaro, 2016). The initiative triggered several other investigations in different disciplines, developing new maps with further evidence, which are still used to demand for deeper changes in provincial and national regulations (Arancibia & Motta, 2019).

Contribution to a CSS methodology

There are two main contributions of collective mapping to CCS. Firstly, collective mapping brings a set of methods that combine participatory activities and co-creation of knowledge with *visual tools* and eye-catching aesthetic results. The simplicity of the tools and the power of its visual results are

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valuable assets to work with marginal communities and/or other social groups with different backgrounds (Finley, 2008; Powell, 2010). Art-based collective mapping is a reminder that the process of participatory knowledge needs to be socially and culturally appropriated. Secondly, collective mapping highlights the connection with agitprop, political campaigns and other tools used by *social activists* which could improve the repertoires of action and theory of change of CSS. Art-based collective mapping produces knowledge that explicitly promotes social and political transformations (Longoni, 2009, Lafuente and Horrillo, 2017, Iconoclasistas, 2016).

Critical points

Sustainability: Weiner and Harris (2003) reflect on the importance of continuous contact with communities and policy makers to improve the likelihood that they appropriate maps, which in turn could evolve dynamically.

Integrative evaluation: several tools, aims, and hybrids of social activism and participatory research fall under the umbrella of collective mapping experiences. Standardisation is difficult. Social transformation is a common goal, but there is no academic research assessing social impact of those practices.

Articulation with public policy: collective mapping has worked in a few cases to change regulations. There is a potential to expand on that. However, the counter-hegemonic characteristic of collective mapping may find some tension in the dialogue with policy-makers wanting to plan and implement projects in those same territories. The challenge will then be to find a common ground of understanding between communities and the State, so that the former's claims and visions could become inputs for the policy making, while avoiding the use of this method to legitimise pre-existent government decisions and vision on policy.

4.2.6.CSOs-led Citizen Science

CSS projects are not generally initialised by universities and research institutions. In order to complement the review of the academic discourse produced in scientific papers, this section includes

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the first-hand practical perspective of the two CSOs within the CoAct consortium, Fundación Ambiente y Recursos Naturales and Federació Salut Mental Catalunya. Moreover, during the course of CoAct, CSO-led CSS project specifically addressing gender equality will be encouraged. For this purpose, three Open Calls will be launched and feminism and other grassroot gender movements (including non-binary perspectives) encouraged to participate.

Fundación Ambiente y Recursos Naturales

Fundación Ambiente y Recursos Naturales (FARN) was created in 1985 to promote sustainable development through law, policy and the institutional organization of the society. Citizen participation is one of the main areas of FARN´s work as citizens have the role and power to contribute to the enforcement of regulations, to build consensus around public policies and invest resources in prevention of environmental damage. FARN´s main approaches involve on the one side, research and advocacy; on the other side, providing training to different social groups and public decision-makers and free legal advice to different collectives involved in environmental conflicts (mining, hydrocarbon extraction, energy projects, deforestation, water pollution) around the country.[4] Thus, many of FARN´s activities involve integrating citizens' opinions. This is the case of legal advice given in environmental conflicts, capacity building and training activities that need to be adjusted to peoples´ needs. However, more recently also other methodologies and experiences that involve seeking people's opinions´ on different policy areas have been integrated.

Participation

The project 'Social monitoring of the Matanza-Riachuelo basin: strengthening the voice and local action' (European Union, 2012-2014) allowed the implementation of a social network based on more than 40 actors to carry out social monitoring and follow-up of the Sanitation Plan and the control of existing pollution in the neighbourhoods and local communities in the Matanza-Riachuelo basin area. This project had four main points: (1) the construction of the network of actors; (2) the construction of an online platform with public information on the different sources of pollution existing in the

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basin; (3) the reports and alerts issued by the members of the network and other local actors that allow the construction of a crowd map with geo-referenced information on the sources of pollution and other critical issues of the basin; (4) presentation of more than 150 access to public information requests that were sent to the different government agencies to follow-up on the different alerts issues by the local citizens.

Another example of our experience would be a workshop called 'Women from the wetlands' that was organized by several institutions, including FARN with the assistance of GROW (specialist on gender issues), to bring together women, socioenvironmental activists from the wetlands in the Paraná Delta, and the coastal strip of the De la Plata river to reflect, promote community strategies, and think about a future National Wetlands Act with a gender lens.

Some of the issues addressed were the lack of job opportunities for women in the region, particularly the island sector; the machismo in the territories and the lack of State policies and specific tools to address gender violence; the naturalization of domestic violence and child sexual abuse; the patriarchy in public institutions such as the judiciary and police; the deficiency or lack of spaces for citizen participation, being the engagement of women particularly difficult; and the absence of a gender approach in the national and provincial environmental legislation developed so far.

Social impact

With citizen´s participation always the centre of most of FARN´s research, advocacy and legal advice strategies the objective of achieving policy makers to listen to what citizens have to say in different issues is a major goal. It is done in the belief that participation helps to improve both development strategies and the quality of the democracy. Participation is strongly linked to social impact. The different projects that FARN has carried out, and particularly using participatory methodologies, has brought some change at the policy level and has helped improve the reach of different policies, i.e. improvement on the information management system in ACUMAR. But more important, they have

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helped creating a joint vision of different issues among citizens, helped to monitor different activities and to bring about ideas and strategies towards social change at the policy level.

An indicator of the success of this project is related to public information. Prior to the project implementation, the Matanza-Riachuelo Basin Authority (ACUMAR for its Spanish acronym) had a large deficit in this area, mainly in terms of producing geo-referenced information and answering requests for information. After the projects, the situation was changed significantly. Moreover, another important product was the implementation of the online platform with geo-referenced information on the social and environmental situation of the watershed.[5] Last but not least, the documentary 'La Vuelta al Río' on the life of people affected by the pollution in the area, and the strategies used to change the situation, was produced.[6] This project served as the background to the current project with CoAct, and the lessons learnt from the previous experience will be included. In these platforms, citizens can bring their knowledge and information, and the organizations involved in coordinating this work, try to bridge initiatives and connect people with similar interests to potentiate their work.

In reference to gender issues being mentioned above, proposals made for an improved draft law on wetlands at the National Parliament for consideration of its members were: include a gender-responsive land use planning process, including surveys with data disaggregated by gender; to generate data on whom are granted financial support through the national fund stated by law for projects on conservation and sustainable use of wetland; that sanctions for intimidation to wetlands defenders are made taking into account existing gender legislation; and to integrate existing international mandates of environmental conventions such as the ones on biodiversity, climate change and desertification, all of which Argentina is a State Party to, and have a Gender Action Plan, and the Ramsar Convention on Wetlands has recently passed a resolution on gender and wetlands. The workshop was enabling spaces and moments for participants to voice their opinions and express their points of views. One of the sessions of the workshop used maps to enable women to identify their territories, their main activities and how these related to one and other by using thread.

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Critical points

These experiences summarize working with people and peoples´ opinion and knowledge on different issue areas and through different tools. Despite the differences, some critical common issues arise – some are more internal (how to do it properly) and some more external (how to get people´s views taken into account). Reflections come primarily from the experience of the first project and others not included.

(1) Participatory methodologies need to be aware of existing power asymmetries regarding gender, age, ethnicity, socio-economic dimensions. These demand sensitivity and reflection on how power imbalances can be addressed by participatory projects so as to reach out to different sectors of society, particularly those in vulnerable situations, and avoid deepening existing inequalities.

(2) There are issues around legitimacy and representation of the outcome of citizen´s contribution. While projects incorporate peoples´ voices, the information they bring about a certain issue, they also include concerns and opinions, and seek to improve a policy, often this information is confronted with critiques. These critiques tend to state that the views expressed are not representative enough because the number of people involved is not significant in terms of population, or they are subjective. These situations happen especially if the view expressed is critical to government or companies' decisions. Some of the information provided (visual material of an industry contamination certain area) are more difficult to be minimized.

(3) There are issues around the reliability of information and sources, and claims that they are not backed in other more ‘scientific‘ evidence. This is also another strategy used to discredit citizens’ opinions, which in many cases are also backed by research.

(4) Last but not least, as in FARN there is little collective consciousness on being working with particular methodologies, and hence, contributing to a specific body of knowledge working on citizen (social) sciences, there is little reaching out beyond the network of organizations working

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in each of the projects to exchange experiences and learn from what has (or has not) worked elsewhere.

Federació Salut Mental Catalunya

Federation Mental Health Catalonia (FSMC) is a non-profit organisation that represents the group of people with mental health issues and relatives, whose right to self-determination is performed by being represented in all decision-making levels of the organisation.

Participation

FSMC's experience with citizen participation in collaborate research projects demonstrates that participatory methodologies contribute to better respond to the needs detected in our community, because they put the person in the centre, to co-create and implement programs to improve people's quality of life. The studies, programs, resources and services that FSMC has developed, co-designed with the participation of people with mental health issues and their families, are based on socially robust and context-embedded knowledge due to people with self-experience engagement from the beginning of the process.

Actually, regarding the topic of mental health there are several official recommendations from the European Commission (EC), the World Health Organization (WHO) and the Convention on the Rights of People with Disabilities on ensuring participation of people with mental disorders and their families, at all levels, including research, design, and implementation of services and programs. FSMC has developed several projects that have been co-promoted, co-designed and co-assessed by the service users themselves and the FSMC's professionals. FSMC works as well on political advocacy to promote their projects in order to facilitate accessibility to care resources and programs and to contribute to policy-making.

FSMC's most important collaborative projects include the development of studies, support tools, services and programs, and co-designing of the evaluation. FSMC co-elaborated an extensive project

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to promote that people with mental disorders and informal caregivers become active agents of the recovery process 'Get active for mental health', also the elaboration of new materials for recovery and self-management of well-being, and booklets to better accompany or the implementation of a collaborative work model to promote integrated mental health care in municipalities.

Social impact

In FSMC's experience collaborate research projects have a very important social impact, because they:

- stimulate citizens to improve the knowledge around their own worries;
- enable informed actions and empowers citizens;
- offer real information on citizen's needs;
- reduce the gap between the 'expert knowledge' and the 'real life knowledges' and allows horizontal relations, which are key aspects for reducing inequalities;
- are a matter of social justice regarding people in situation of vulnerabilities have the right to participate on the design of solutions for their own situation.

For FSMC it is very important that the projects they work on, not only allow a better understanding of the reality of people with mental health problems and their families' community. It is essential to take into consideration that citizen participation must also translate historical demands into policies that allow real changes to improve care services, life satisfaction and a real inclusion of people.

To achieve the goals mentioned above, it is essential that the collaborative projects developed include rigorously impact evaluation measures. For this reason, the projects carried out by FSMC are always assessed by internal quality monitoring processes and external to improve the necessary involvement of the represented groups in the interpretation of the results.

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Contribution to CSS methodology

CSS is aligned with the empowerment of people, one of the main values of FSMC. FSMC understands that CSS must generate not only social change and collective transformation, but also individual growth and personal empowerment. Therefore, CSS must not only contribute to reach collective goals but also entail evident individual profits.

Furthermore, CSS can contribute to drive awareness and self-reflection on the reality of people with mental health issues and to provide new insights for the mental health community care model to complement and improve what has been achieved from institutions with an essentially professional vision, where people with self-experience and their close social support network are not represented in levels with greater decision-making power. Giving voice to the people directly involved in the subject of CSS research may strength, in a constructive way, the social activism's fight to face down lobbies with a greater power of influence, but sadly far from the citizens' real needs and concerns.

Critical points

FSMC's experience in participatory projects has allowed them to detect some critical points that need to be further reflected:

(1) Encourage the participation of a greater number of people, since first-person mental health and family members activists are often the same in different forum and this fact generates significant personal burden.

(2) Sometimes, the results obtained by civil social organisations are not taken enough into account. We must continue lobbying to be recognized not only as providers of valid knowledge, but also as legitimate agents to boost real changes and improvements.

(3) Participative methodologies and collaborative processes are often developed in the project planning and design phases, but not enough in the results interpretation phase, where professionals' voice has a greater influence, partly due to the gap of some required technical literacy.

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(4) Certain CSS aspects represent a barrier to greater involvement of certain community groups not familiarized with the scientific context, technical language or new ICT.

4.3. Transversal methodologies, methods and approaches for R&I Actions

4.3.1. Open Science

Based on the idea that scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process (Nielsen, 2009), Open Science practices demand maximum transparency and shareability in knowledge production and knowledge transfer, as well as the participation of (all) relevant stakeholders in the scientific process (Mayer, 2015). However, Open Science also brings new challenges in terms of research-ethical and legal regulations, such as reciprocity of access, data protection, and data security, as well as with regards to alternative exploitation models and licenses (Nosek et al., 2015).

Historical background

Open Science initially started as a grassroots movement in the tradition of free and open software that developed into an important cross-cutting issue in the international RTI policy arena. Parallel to numerous decentralised bottom-up initiatives on all continents and carried by increasing institutional backing by non-profits (ORFG, 2020), commitments to Open Science have been made on both a national and international scale (OECD & World Bank, 2020). The Human Genome Project, formally launched in 1990, is regarded as one of the most prominent and ground-breaking examples of international cooperation on the premise of openness (Gitlin, 2013). In the same decade, countries in South America first developed national and transnational Open Access (OA) platforms. In the USA, the National Institutes of Health has had an OA mandate since 2008 (Alperín et al., 2008), while the National Science Foundation adopted a public access policy in 2016 following a 2013 White House memorandum (OSTP, 2013). In Asian, African, and European countries, too, OA mandates tied to national funding have been arising since the 2010s (UNESCO, 2015b, 2015a). In 2017, the G7 Science Ministers signed a memorandum addressing the need of incentives and infrastructures supporting

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open research (G7 Science Ministers, 2017). The WHO, OECD, UNESCO, all feature Open Science prominently as the main objective to change the global scientific system and to reach the Sustainable Development Goals, and most recently to tackle the global COVID-19 pandemic (Goldacre et al., 2015; OECD, 2020; UNESCO, 2020). The European Union made OA to publications mandatory in various research funding bodies since 2014. For the next European research framework programme from 2021 onwards, open science is planned as the 'modus operandi'.

Broadly speaking, Open Science entails seven key dimensions: (1) OA stands for unlimited and free access to scientific information (incl. publications, primary and metadata, source texts, and digital reproductions) on the internet using open licenses. (2) Open Research Data delineates research data that are made freely accessible worldwide via the Internet, which is possible if there are no technical, legal, economic, or ethical reasons preventing it. Open research data can support scientific integrity, increase transparency, and allow for the reuse of research data and results. (3) Open Methods means the opening and making available of scientific methods and source codes, making results of scientific research not only more accessible and comprehensible but also reproducible, while also allowing for further development of methods based on existing ones. (4) Open Evaluation signals openness in scientific evaluation through Open Peer Review (which might include broader participation in public review processes) and Open Metrics (which means openness of data, methods, and results of bibliometric analyses used for evaluation). (European Commission Expert Group on Altmetrics, 2017) (5) Open Infrastructures point to open and reusable systems and databases, using open source software to create data, open licenses for publishing, and open interfaces (Open APIs) to make data available. (6) Open Education is based on the principle of making education freely accessible so that all members of society can potentially benefit from it. This requires the free use, processing, and further distribution of appropriate teaching and learning materials. (7) CS intends to broaden participation in all fields and at all levels of science, from research design to data gathering, data analysis, evaluation, as well as dissemination and exploitation of research results. CS is regarded as

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an important aspect of opening science in terms of democratization and broader participation in scientific knowledge production (Vohland & Göbel, 2017).

Epistemology, methodologies and methods

The idea of openness has been operationalised into a wide range of resources and services, as well as policies and behaviours. Pomerantz and Peek (2016) distinguish a multitude of meanings of 'open', and line up many definitions and common ancestors, including the concepts of 'open societies' (Popper, 1994) and ‘free software’ (Stallman, 1992), that articulate openness for everything from hardware to knowledge, while pointing to the underlying moral economies (Bacevic & Muellerleile, 2018; Daston, 1995). Openness as a virtue is regarded as a central aspect of scientific integrity. The normativities of open science can be differentiated via their attached (and often overlapping) schools of thought, five of which Fecher and Friesike (Fecher & Friesike, 2014) have identified: the public school, with emphasis on accessibility of knowledge creation; the democratic school, with emphasis on equality of access to knowledge; the pragmatic school, with emphasis on collaboration; the infrastructure school, with emphasis on the technological architecture; and the measurement school, with emphasis on alternative impact measurements.

Openness in the social sciences is on the rise, even though sharing data, pre-registering analyses and replicating research results have been marked by controversy (Christensen et al., 2019). The increase of adoption goes along with digitalisation, changes in institutional and funding policies, and increasing demands of evidence-based policy. In the past, limited transparency in the social sciences has contributed to a crisis of reproducibility and credibility. For many, openness is the right means to improve accountability and trust in the social sciences (Hecker et al., 2018).

Degree of and measures for participation

Participation in Open Science has two sides: first the engagement of researchers with Open Science, and second the access to and engagement with scientific activities for non-scientists, like CS. While support for open science is growing in almost all disciplines, long term motivation of researchers to

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open their research is challenging. Competition, the intellectual property regimes, and lack of time are often mentioned as disincentives to participation. Mechanisms by which researchers can engage with Open Science need to embrace both bottom-up values and community driven measures, as well as top-down policies and legal frameworks (Ali-Khan et al., 2017; Leonelli, 2017). Studies show that opening access to publications, data, and methods increases cooperation in research and has many other benefits (Arza & López, 2017; Blümel et al., 2019; McKiernan et al., 2016). Examples of open methods in the social sciences include open sourcing program codes, collaborative replication studies, opening workflows such as annotations and coding schemes, sharing data and metadata, citizen generated data, and many more. An open and participatory CSS promotes inclusion of citizens in all stages of the research process (Mayer et al., 2018). This includes the definition of the research questions and the evaluation of results and outputs.

Social impact and measurement

During the COVID-19 pandemic, but also long before, institutions such as the WHO have repeatedly emphasised the need for open science (Chan et al., 2009). They call for the mobilisation of decision-makers to open up research across borders and for improved communication between science and politics in order to solve problems faster and more efficiently (UNESCO, 2020). The advantages of Open Science for research have been well documented so far. OA in publications and data brings a citation advantage and thus more visibility (Piwowar & Vision, 2013). Public funders get a better return of investment through increased cooperation and the reusability of knowledge in other contexts (Blümel et al., 2019). Opening science encourages participation, while access not only to research results, but also to researchers enables wider public discourse on research topics and education (DITOs consortium, 2017).

Contribution to a CSS methodology

For the social sciences, more openness certainly means the possibility to overcome the current crisis of trust and to contribute to inclusive solutions – from local to grand challenges – in much closer

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cooperation with the research subjects. Openness contributes to the creation of knowledge commons and shared resources, which allow for better knowledge transfer. Moreover, openness in the social sciences helps to address issues of inclusion and empowerment of research subjects, co-researchers, as well as to address issues of the academic reward and incentive systems. Open social science can help to foster participatory procedures of representation and decision making in science and policy realms, while tackling credibility, reliability, and quality of knowledge claims as well as trust in evidence.

It is essential for CSS as mediator of societal change that quality relates not only to the data or scientific method, but also to the ways in which participation is enacted, and decision making is broadened beyond academic realms (Mayer, 2015; Mayer et al., 2018; Vohland & Göbel, 2017). Open Science as modus operandi brings substantial transformation to the relationship of researchers and research subjects. Research design, data, methods, and results should be (re-) usable not only for social scientists but also for stakeholders taking part in the creation of those data, and beyond.

Critical points

Openness as well as participation in citizen social science will always vary by degree. Both cannot be reduced to mere binary yes/no or all/nothing conditions. The challenges, however, concern precisely this degree of openness and participation. Who is something open to (Mirowski, 2018; Tkacz, 2014)? Openness could also turn into a threat for people or groups in an exposed or marginalised position. Therefore, a research design has to consider openness and participation from the start. The FAIR principles of findability, accessibility, interoperability, and reusability of data in citizen social science are not only important for researchers, but also for all other participants in the project (Landi et al., 2020). Research standards are crucial, but on the other hand, not enough. Data and methods often must be translated to benefit the participants, protect their privacy and meet their expectations. Open and participatory Citizen Social Science can only succeed with a governance that handles and balances different visibilities, epistemologies, and velocities.

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4.3.2.Crowd Science

Historical background

Crowd Science developed in the early 2000s with several Crowd Science projects such as 'Foldit', 'GalaxyZoo' and 'Polymath' becoming popular (Franzoni & Sauermann, 2014). Some authors place Crowd Science in a line with the CS projects of the Cornell Lab of Ornithology, paired with the peculiar characteristic of online/digital participation (Kasperowski & Kullenberg, 2019; Franzoni & Sauermann, 2014). The early Crowd Science projects were drawing on the concept of crowdsourcing, originating from the (digital) economy and named by Jeff Howe (Eklund et al., 2019). Since then, the term has been used by a broader set of projects, usually referring to activities where a crowd is involved in a problem-solving task in order to produce a scientific outcome (Eklund et al., 2019). In 'Foldit', using gamification, thousands of participants contributed to identify protein structures; in 'GalaxyZoo', participants classified pictures of Galaxies in an online database, with some even discovering a new type of galaxies (Franzoni & Sauermann, 2014; Straub, 2016).

Scientific fields and topics

Crowd Science projects are so far most common in natural sciences but are increasingly applied in a diverse range of fields including humanities and social sciences (Franzoni & Sauermann, 2014; Scheliga et al., 2018; Wiggins & Crowston, 2015; Lafreniere et al., 2019). Most of the papers included in this review, discuss projects in astronomy, biochemistry, mathematics, geography and history, but there are also several Crowd Science projects in medicine and public health, environmental monitoring, culture and education. Crowd Science is overlapping with the fields of neogeography, especially when involving volunteered geographical information and open software development (Kullenberg & Kasperowski, 2016; Haklay, 2013; Nov et al., 2014). Topics range from astronomical classification (Straub, 2016), radiation (Brown et al., 2016), genealogy, public history, local or historical cartography (Aucott et al., 2019; Lafreniere et al., 2019), climatology or weather records (Sieber & Slonosky, 2019; Eveleigh et al., 2014), health related research (Wiggins & Wilbanks, 2019;

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Moore et al., 2019) to environmental topics and activism (Dickinson & Crain, 2014; Hano et al., 2020; Jakositz et al., 2020). On a methodological and organizational level, recurring topics are citizens motivations for participating (Aucott et al., 2019; Eveleigh et al., 2014; Nov et al., 2014), project initiator's actions to keep citizens involved over a longer period of time, task design, processing of citizens' input and capabilities of the crowd (Prpić & Shukla, 2014; Scheliga et al., 2018), conflicting interests from stakeholders, authorship and access and use of the data produced (Franzoni & Sauermann, 2104; Shun-Ling, 2019; Holeman et al., 2016).

Epistemology, methodologies and methods

With crowdsourcing based in business and early Crowd Science projects coming from natural sciences, crowdsourced CS projects are often discussed in terms of game theory, theories of problem solving and organizational theories (Scheliga et al., 2018; Prpić & Shukla, 2014; Dickinson & Crain, 2014). Often, these theories inform how research is split into small pieces that are processed by the crowd and results integrated by project initiators. Open data and open source software development movements as well as the more general CS discussion about democratization of science are other relevant influences on Crowd Science projects (Brown et al., 2016; Scheliga et al., 2018). The availability of data, procedures and results to the citizen scientists involved and the wider public is often discussed as an important aspect (Straub, 2016; Shun-Ling, 2019; Lafreniere et al., 2019) and a crucial feature for differentiating Crowd Science from crowdsourced 'traditional' research (Franzoni & Sauermann, 2014). Digital platforms such as 'Zooniverse' hosting various CS projects have come to be an important tool, where participants can familiarize and choose projects they like to engage in, while project initiators can find a pre-existing and adaptable infrastructure. Crowd Science projects use a diverse set of methods. Common methods include tagging, gamification, transcription, mapping techniques, but also online-discussions facilitated by project leaders.

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Degree of and measures for participation

In the reviewed literature, contributory Crowd Science projects prevail. This is in line with the original concept of crowdsourcing, with a project initiator sending out a task to be accomplished by an (anonymous) crowd (Eitzel et al., 2017). Accordingly, citizen scientists are often referred to as 'contributors', 'volunteers' or 'participants'. Citizen scientists are involved in publication processes or exceeded the role usually planned for them by the scientists who had started the project and pose research questions of their own (Eveleigh et al., 2014; Straub, 2016). However, the degrees of participation now range from mere contribution of a sample (Jakositz et al., 2020) to some citizen-led Crowd Science projects (Brown et al., 2016; Scheliga et al., 2018). Participation is most often discussed with regard to the types of tasks accomplished by citizen scientists and differing pattern of their involvement. Participation is discussed with some reference to classifications of participation in CS projects in general (Shirk et al., 2012; Haklay, 2013) and Haythornthwaite's (2009) differentiation of online collaboration as another recurring point of reference (Eveleigh et al., 2014; Aucott et al., 2019). Participation of the crowd already in early stages of the research process is scarce (Scheliga et al., 2018). Still, some projects were started outside of academia, often tackling health and environmental issues and started by NGOs or comparable organizations (Brown et al., 2016; Scheliga et al., 2018). Potentials to increase participation are being explored by combining crowdsourcing methodology with other approaches, such as focal groups, public design activities and social media (Lafreniere et al., 2019; Brown et al., 2016; Dickinson & Crain, 2014).

Social impact and measurement

Measures for social impact are rarely discussed explicitly, although there is a broad debate about the social impact of Crowd Science. Especially Crowd Science projects that were started by citizens or citizen organizations focus strongly on social impact, as well as Crowd Science in the fields of public health, medicine and geography. In the reviewed papers, concern with impact in the scientific field often prevails. Impact in the scientific field is mostly discussed regarding the huge amounts of data that can be accessed and processed, the reaching of highly specialized knowledge or specific social

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groups. The disclosure of procedures, data and finding to the public and other researchers is discussed as a distinctive aspect to broaden the social impact of research, thus legitimizing public funding for scientific endeavours (Franzoni & Sauermann, 2014; Shun-Ling, 2019). A lot of papers discuss the potential of Crowd Science to extend the accessibility of scientific research and increase scientific literacy (Brown et al., 2016; Straub, 2016; Sieber & Slonosky, 2019), through a relatively low threshold to engage with scientific research, enabling citizens to be involved with up-to-date-scientific research and the familiarity of citizens with their own data (Wiggins & Wilbanks, 2019). Besides that, Crowd Science is reported to contribute to consciousness raising about their respective topics, potentially drawing attention of a lot of people (Moore et al., 2019; Franzoni & Sauermann, 2014; Jakositz et al., 2020). Even when no longer actively participating, a lot of people seem to remain interested in further proceedings of the respective research project and topic (Eveleigh et al., 2014). In order to increase social impact of Crowd Science, other than scientific aims are and should be integrated into research design, such as educational and policy-oriented objectives of stakeholder organizations (Aucott et al., 2019; Hano et al., 2020).

Contribution to a CSS methodology

Crowd Science has some promising characteristics for a CSS methodology. The quite developed infrastructure of Crowd Science platforms and the knowledge created during the last decades, allows citizens to find projects and topics of interest, and project initiators to tap into a pre-existing technical and organizational infrastructure (Franzoni & Sauermann, 2014). With the capacity to create, process and analyse large amounts of data, Crowd Science can provide an important component for transformative scientific as well as policy-related endeavours. Crowdsourced CS projects attract large numbers of citizens to a research project, and in doing so, contribute to awareness and scientific literacy. Another promising characteristic, especially for health-related issues, is the capability to reach out to citizens from disparate regions possessing highly specialized skills or who are concerned with a specific problem (Franzoni & Sauermann, 2014; Wiggins & Willbanks, 2019). In some cases, the anonymity granted to contributors could prove useful for CSS (Eklund et al., 2019). Using digital

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technologies and chopping tasks into small units, Crowd Science is often characterized by a low threshold for involving with research. Citizens can acquire specific knowledge about scientific procedures and technologies, and, if well designed, can chose how profound they want to engage with a project. The possibility of participation for citizens without needing to understand all aspects of a project is a double-edged sword. Enabling citizens to participate more thoroughly in the research process partly depends on provision of research methods and results in a way that is understandable and accessible for lay persons as well, and/or on suitable knowledge sharing processes (Straub, 2016). As projects like 'SafeCast' (Brown et al., 2016), which reacted to the Fukushima crisis, have shown, Crowd Science can be a tool for civil society to reach out, allow for rather quick and real-time data collections when needed, but have the potential to transform into a continuous scientific, political and educational effort for a topic of high relevance for citizens. In the case of 'SafeCast', even spin-offs of the project with no organizational connection evolved.

Critical points

With these possible contributions in mind, we will conclude with some critical aspects concerning Crowd Science observed during the review. With regard to the often limited inclusion of citizen scientists in research questions and design, ways for balanced partnerships with the public in Crowd Science are to be found, and research designs that are capable and committed to a balancing of power dynamics and possible impacts on communities and people affected (Eitzel et al., 2017; Lafreniere et al., 2019; Hano et al., 2020). Aspects discussed include the use and accessibility of produced data and results, case-specific ethical challenges and privacy issues, providing thorough information on tools and methods, and responding to participants resistances and critiques (Wiggins & Wilbanks, 2019; Eklund et al., 2019). Another controversial aspect concerns dealing with the tension present in Crowd Science between involving collective effort and knowledge for scientific and societal change, and the use of a crowd as cheap, alienated labour in a competitive, neoliberal research environment, potentially assuming state responsibilities (Eklund et al., 2019; Scheliga et al., 2018; Eitzel et al., 2017; Brown et al., 2016). With regard to science policies and scientific practices, there are critical remarks

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to work against the equation of Crowd Science with CS in public perception (Wiggins & Crowston, 2015; Eitzel et al., 2017), and to aim for an integration of Crowd Science into existing scientific practices instead of building of parallel, alternative structures, tapping deeper into discussions of standards, e.g. for publication processes, availability of data and publications, and authorship issues (Shun-Ling, 2019; Scheliga et al., 2018).

4.3.3. Citizen Generated Data

Historical background

Recent years have seen a proliferation in the availability of different types of data from different sources, including not just statistics, but also data from sensors, satellites, drones, online platforms, mobile phones and numerous other digital devices and infrastructures, as well as from individuals (Lämmerhirt et al., 2018). The concept of Citizen Generated Data (CGD) is used in many different ways, with connotations in different fields such as citizen science, citizen journalism, crowdsourcing, witnessing, civic participation, participatory design, patient involvement and social media listening. These ways of envisaging CGD partly result from different traditions which pre-date the digital technologies upon which they often draw – from self-taught naturalists filling notebooks with observations in the 1980s, to 'social audits' which grew to prominence in the 1980s and 1990s (Lämmerhirt et al., 2018).The international non-profit organization CIVICUS defined CDG as '[...] data that people or their organisations produce to directly monitor, demand or drive change on issues that affect them. It is actively given by citizens, providing direct representations of their perspectives and an alternative to datasets collected by governments or international institutions' (Datashift, 2015).

There are many ways of doing CGD, including different ways of configuring relations between each of the three parts of the phrase, 'citizen', 'generated' and 'data' (Lämmerhirt et al., 2018):

- *Citizens* may be enrolled as sensors, auditors, monitors, reporters, community members, observers, co-investigators, analysts or platform users.

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- *Generating* may involve identifying, tagging, transcribing, compiling, mapping, describing, evaluating, quantifying, photographing, recording, translating, narrating, deliberating, writing, sensing, conceptualising or noticing.
- *Data* may result from a wide variety of devices, methods and infrastructures, including scientific instruments, paper surveys, online platforms, mobile phones, maps, satellite imagery and documents.

Scientific fields and topics

Different actors associate CGD with different meanings, definitions, practices and projects (Gray, 2018). Nonetheless some of all aspects of CGD are studied across disciplines as varied as geography (Connors et al., 2012), environmental research (Shirk et al., 2012), statistics (Piovesan, 2017), political science (Haklay, 2015) or development studies (Holeman, 2016). A range of issues and goals are addressed through CGD projects, from land mapping, to public service monitoring to air pollution monitoring (Gray et al., 2016). More than the topics they can cover, which are limitless, CGD projects are defined by the type of action that they inform: agenda-setting, designing solutions, implementing solutions and monitoring and evaluating solutions (Lämmerhirt et al., 2018).

Epistemology, methodologies and methods

CGD may be produced in ways which differ from professional knowledge production: they may be produced in ways which depart from established conventions to obtain the quality, interoperability and verifiability of data and sometimes abide by 'good enough' standards for operational use, different from those of established official professional statistics (Lämmerhirt et al., 2018). CGD is different, not better or worse than other forms of knowledge production. It can bring citizens to the foreground of research, representing their views and experiences in ways that other forms of data capture cannot. It can bring local knowledge and expertise to the forefront and reach places that other data capture methods cannot. It can also prove a solution where other forms of collection would be prohibitively expensive, or logistically impossible (Lämmerhirt et al., 2018). Recent research

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starts to provide a more nuanced answer to the question when citizen-generated data is good enough. Legal and public policy-oriented research suggests that higher quality is required the more likely the governmental use case involves legal and policy actions. (Gabrys et al., 2016)

CGD can include many methodical steps. Analysis of CGD projects allow the identification of a common non-linear framework which includes the following phases: definition (consultation, problem scoping), production (sample collection, field survey), enrichment (compiling, tagging), analysis (triangulation, enumeration) and dissemination (stakeholder meetings, campaigning) (Lämmerhirt et al., 2018).

An overview of case studies highlights the variety of methods deployed as part of CGD projects: deploying monitoring equipment; mapping with drone of GPS devices; undertaking new surveys; combining multiple existing databases; scraping and aggregating data; cross-referencing official, news and social media sources; creating crowdsourcing mechanisms (Gray et al., 2016).

Degree of and measures for participation

CGD is characterised by people's involvement in the data production process. Several models have been developed to note different levels of engagement along the data production process, ranging from contributory to co-created initiatives (Shirk et al., 2012). These models emphasize that people can get enrolled at different stages in a CGD initiative, and are an intuitive way to differentiate participatory models, as seen in the figure below:

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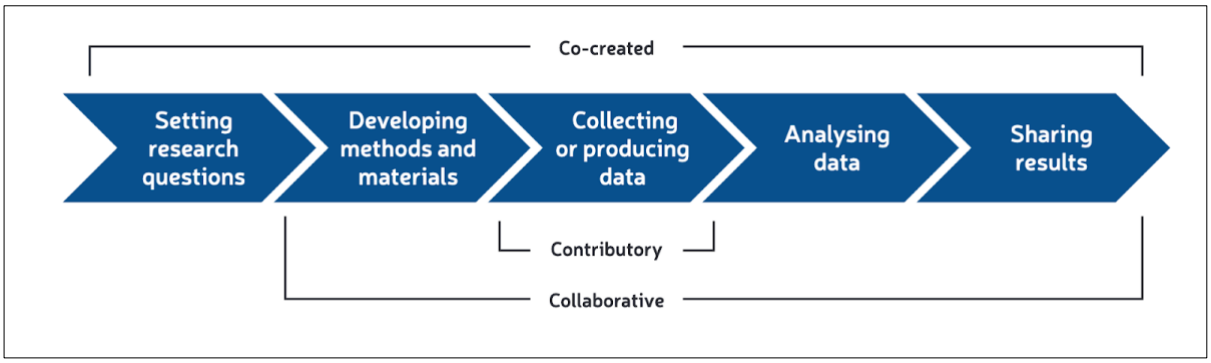

Figure 14: Stages of engagement in citizen science projects (Shirk et al., 2012)

But not all participation is active: a group of citizens may passively produce data by using tracking devices or by installing air pollution sensor networks that gather data on their behalf (Lämmerhirt et al., 2018).

Social impact and measurements

Regarding to Lämmerhirt et al. (2018), in the context of CGD, the involvement of citizens can be understood in different ways in relation to professionalised institutions of knowledge production, such as:

- Enabling citizens and organisations to foreground, describe and help addressing problems that are otherwise unnoticed in existing data collections.
- Introducing political dynamics around problems, which may open up spaces for collaboration, but also face resistance if the problem is not acknowledged or de-prioritised by the government.
- Producing evidence that may otherwise be ignored because it's politically awkward (e.g. challenging the views of established institutions and helping them to evolve with society).
- Collecting information which would otherwise be considered prohibitively expensive (e.g. nationwide wildlife counts).

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- Gaining new perspectives drawing on local insights and expertise
- Checking plans against experiences that are not otherwise readily available (e.g. ground-truthing and verification).
- Enabling civic involvement and participation (e.g. involving communities in surfacing and responding to issues.

CGD practices have led to various forms of engagement and elicited several different kinds of responses from public institutions, including: investment in further data collection operations; adoption of the proposed data collection practices; engagement with citizen-generated and civil society data collection; official support for the proposed data collection practices; endorsement and recognition for citizen-generated and civil society data collections (Gray et al., 2016).

Contribution to a CSS methodology

The fact that CGD projects may not always and immediately conform with these established practices of knowledge production does not mean they are less valuable (Lämmerhirt et al., 2018). Intrinsic data quality factors such as trustworthiness, accuracy, reliability and representativity can be comparable to professional or scientific data collections provided task difficulty is appropriate and sufficient trainings are conducted (Kosmala et al., 2016). The main contribution of CGD to CSS is to provide methods and case studies which can be borrowed from to design CSS projects. Another major contribution of CGD is the ability to deliver baseline research: CGD may provide otherwise unavailable data by for instance by increasing the granularity of existing data (Lämmerhirt et al., 2018).

Critical points

The reliance of CGD on alternative models of knowledge and data generation means that it is exposed to a number of risks, the main one being the inability to translate the generated data into fruitful advocacy, due to reasons outside of the project's control such as non-cooperative official institutions. In some contexts, the data collection activity itself may be risky or even illegal. Finally, the replicability of CGD projects is not always certain (Gray et al., 2016).

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A few potential technical issues are also necessary to monitor, including: lack of representivity; Lack of methodological rigour; no complementarity with official data sources; lack of interoperability. The uncertainty about the persistency of the initiative is also a factor that may hinder a CDG project (Piovesan, 2017).

Lastly a number of stakeholder-related issues also exist, as CGD initiatives by nature Wand & Wang, (1996) include many different stakeholders. Stakeholders have different priorities, values, or responsibilities, and are affected differently by an issue. Stakeholders have certain capacities to engage with an issue, and are prepared differently to act upon it. Some actors may lack the literacy, knowledge, time, or interest to engage with complicated data (Lämmerhirt et al., 2017). Each stakeholder may perceive and value information differently, necessitating a user-centric design for CGD. Such a design puts the issue, the intended message, and its stakeholders before the data. (Wand & Wang, 1996).

4.3.4.Hackathons

Historical background

Hackathons are events where domain experts, including software developers, designers, and relevant specialists, work together to create novel tooling to solve specific problems during a short time frame. The name originates from the words ‘hack‘, meaning intensive programming, and ‘marathon‘, as it requires endurance with few breaks. Hackathons have evolved from impromptu pizza parties to global events to solve complex problems in creative ways. The events begin with an introduction of the general problem to be worked on, followed by individuals pitching their solutions, then team formation. Teams intensively work together over a short period of time to create tooling to solve the problem, and then end the event by presenting their solution. Most hackathons have a jury that judges these final presentations and select a winning them which is awarded a prize of some sort, ranging from monetary rewards to job offers. As hackathons have grown in popularity, they have also

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grown more varied in their participants, goals, themes, and overall structure (Briscoe & Mulligan, 2014; GIZ, 2016).

Scientific fields and topics

While hackathons were originally events focused on computer programming and building new technology, they have now expanded into other fields such as civic engagement, healthcare, design, and open data (Uffreduzzi, 2017; Htun, 2019). For example, recent groups have hosted hackathons to work on improving diversity and inclusion in academic science, creating novel healthcare solutions, and generating ways that the public can contribute to policies affecting them (Htun, 2019).

Additionally, hackathon sponsors and organizers fall into several categories. Initially, they were mostly organized by companies, but they are now frequently organized by non-profits, charities, and other organizations focused on community engagement (GIZ, 2016). Many companies sponsor internal hackathons to create new technology for the company to use. For example, a successful creation for an internal Facebook hackathon was the 'like button' (Briscoe & Mulligan, 2014).

Generally, hackathons involve coding to some extent in each project, but there have been some events called hackathons that have no computer programming involved (Uffreduzzi, 2017).

Epistemology, methodologies and methods

Hackathons are like marathons in that they span many hours, from 8 up to 48 hours, and participants typically rarely rest (Uffreduzzi, 2017). They follow a general template consisting of five parts: organizers announce a theme and set a date; participants pitch ideas and form teams; teams brainstorm creative solutions according to the theme; teams implement those solutions in a prototype (typically by coding); teams prepare and present a demonstration of their prototype solution (Mohajer Soltani, 2014; Uffreduzzi, 2017).

Organizers must decide on a theme for the hackathon, which could be based on using a specific technology or coding language – like Java – or solving a large societal problem – a 'Culture Hack'

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– (Briscoe & Mulligan, 2014). Several analyses have shown that properly defining the theme and communicating it to the participants is vital to the success of the event (Mohajer Soltani, 2014). Another important aspect of organizing a hackathon is deciding upon the prize. Most hackathons have a prize of some sort that is awarded to the winning team or teams by a jury, and the quality of this prize is an important factor for the overall success of the event (Briscoe & Mulligan, 2014; Mohajer Soltani, 2014). Prizes include monetary compensation, job offers, or sponsorship for future development of the prototype (Briscoe & Mulligan, 2014).

Degree of and measures for participation

Hackathon participants' backgrounds are usually tech-focused, but as the term hackathon has broadened to include more events, the participants' backgrounds have also broadened. At a typical hackathon, designers, field experts, students, marketers, writers, and other non-developer professionals can be found (Briscoe & Mulligan, 2014; Uffreduzzi, 2017). In many ways, hackathon participants are demographically similar to those that work in the tech fields: they are predominantly male, caucasian, and young. Female participants are underrepresented, and in one study, the percent of female attendees was similar to the percent of females employed in the tech industry (12.3%) (Briscoe & Mulligan, 2014). Similarly, the average age of attendees is between 25 - 34, which reflects the reported age inequalities in the tech industry (Briscoe & Mulligan, 2014). There are many reasons why hackathons lack diversity, such as unwelcoming environments created by unconstructive attitudes, discrimination, and the prevalence of negative stereotypes. Also, the perceived nature of hackathons as being competitive, unsociable events with little sleep or comfort can discourage people from underrepresented groups to join. Increasing diversity of participants (demographics and profession) should be a high priority. Several reports show that teams or projects made up of diverse participants are more successful; having a combination of attendee backgrounds allows participants to provide their expertise at various stages (Briscoe & Mulligan, 2014; Uffreduzzi, 2017).

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Participants' reasons for attending hackathons also vary. For instance, attendees might be motivated by the competition and are there to win the prize. They could also be present to explore or dabble, in which they are motivated by learning new skills and might work on multiple projects. There are also participants that only observe and do not directly contribute to specific teams (Kos, 2019). When asked why they attended, one study found that the most common answer was to learn, followed closely by to network. Other top answers included to change the world, to win prizes, and to get free pizza (Briscoe & Mulligan, 2014).

Another aspect of participation is how individuals work together with their teammates. There are several collaboration styles that teams show, such as the traditional team, where all members work collaboratively on a shared goal. There can also be collaborative groups, made up of several teams, working on similar projects that all gain from this collaboration. Finally, there are lone participants that hop from project to project, with the goal of helping several unrelated teams (Kos, 2019).

Social impact and measurements

Hackathons are known for creating new ideas and prototypes quickly, and therefore have the potential to have rapid social impacts. An example of this is the development of novel medical tools during hackathons between the tech community and medical professionals (Uffreduzzi, 2017). Bringing these groups, which do not normally collaborate, together to innovate during a hackathon allows these experts to communicate and solve problems in a novel way. Furthermore, hackathons can bring new tooling to communities in need. Hackathons have shown that innovating together is more successful than innovating alone (Uffreduzzi, 2017).

Another positive social impact of hackathons is that attendees can learn new skills or find new job opportunities. Additionally, groups and organizations can use hackathons to recruit new members and build up their communities (Uffreduzzi, 2017; Briscoe & Mulligan, 2014).

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Contribution to a CSS methodology

There are many aspects of successful hackathons that CSS could learn from and implement.

- *Innovation centres:* Hackathons provide a space and time for groups of people to collaboratively work on solving complex problems. They are self-limiting, in that prototypes must be produced within a short timeframe, so projects cannot suffer from scope creep. Creating such a space allows participants to try new ideas while limiting the repercussions of failure. This stimulates creativity, encouraging innovative solutions to problems (Uffreduzzi, 2017).
- *Incorporate other viewpoints:* Hackathon teams made up from more diverse people produce better solutions, and CSS should take this lesson forward (Uffreduzzi, 2017). These events provide a space for people from different backgrounds to come together in ways that they normally would not. Having other viewpoints present and listening to those viewpoints can lead to novel ideas. In the same vein, hackathon-like events allow for participants to gain perspectives from different stakeholders, such as users or community members that will be affected by the tooling or idea created at the event.
- *Open practices:* Implementing open practices in hackathon events can create public value. Civic hackathons allow for public participation to solve problems affecting specific communities (Yuan & Gasco-Hernandez, 2019). Openly publishing and licensing outcomes from a hackathon improves transparency and accountability, especially for civic-themed events.

Critical points

While hackathons can create revolutionary solutions to problems, the events themselves face several challenges. A critical issue is *the lack of diversity of participants* (Uffreduzzi, 2017). It has been clearly shown that women are underrepresented at hackathons, but there is less literature nothing other demographics. While this is a general trend in the tech industry, it cannot be written off as beyond

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the scope of hackathon planners' responsibilities to improve by working to become more welcoming and inclusive to all.

Another major critical point about hackathons is the creation of 'vapor ware' or 'abandonware' (Uffreduzzi, 2017). These are names for prototypes that are created only for the hackathon and are then abandoned after the event ends. Critics question the usefulness of hackathons due to the proliferation of these abandonware creations – is actual innovation happening?

The overall organization of hackathons is also frequently criticized. For example, hackathons can be viewed as being overly competitive, mostly due to the time constraints and the heavy focus on winning prizes. Other organization critiques include poor team formation, poor communication between participants, and a lack of overall theme consistency from the organizers. Also, hackathons deal with licensing and intellectual property issues.

4.3.5. Maker spaces

Historical background

'Makerspaces are informal shared spaces located in communal, educational and increasingly also commercial settings, which provide their members with access to technologies, resources and most importantly a community of peer learners for making.' (Ahmadi et al., 2019)

Makerspaces are local, physical representations of a global community of makers. They provide collaborative environments for people with shared interests, especially in crafts, technology, design and product development to gather and share knowledge, skills, and equipment (Halbinger, 2018; Hennelly et al., 2019). Makerspaces have different typologies, depending on their contexts (Geser et al., 2019; Lindtner et al., 2016; Rosa et al., 2018). They can be embedded in communal or public institutions like museums, libraries or educational institutions as well as commercial organisations or work as stand-alone for-profit or non-profit centres (Ahmadi et al., 2019; Irie et al., 2019). Most of

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the latter emerge organically from grassroot communities, often led by a handful of motivated makers (Johns & Hall, 2020).

Contemporary makerspaces, as hubs for digital Do-It-Together culture, have emerged from the European hackerspace communities of the 1990s (Lindtner et al., 2016). Most makers identify as part of the global maker movement, based on hacker ethics, DIY and free software ideologies (Bean & Rosner, 2014; McCarthy & Mayer, 1977). The maker movement is driven by a common understanding that democratizing access to tools and technologies (Ahmadi et al., 2019; Blikstein, 2013; Tanenbaum et al., 2013) will "revolutionize the means of design, production and distribution of material goods" (Mota, 2011), and would thereby challenge and disrupt existing socio-economic systems (S. Bardzell, 2018). Openness, Sharing, and Inclusion are the driving values of the community. Transnational collectivity is expressed in communities, such as the Global Innovation Gathering or the pan-African Open Science and Hardware community.

Scientific fields and topics

Makerspaces have gained scholarly attention in Social Sciences – including the fields of Social and Technology Studies (STS), Human-Computer Interaction (HCI) and Participatory Design (PD), Economics (above all in the fields of Entrepreneurship, Management and Organizational Studies) and Applied Sciences. Each of these disciplines explores makerspaces through different lenses.

Social Science research focuses on inclusion and diversity, ranging from acknowledging everyone as an expert to critically assessing biases towards the equal engagement of marginalised groups (J. Bardzell & Bardzell, 2013; Keune et al., 2019; Tanenbaum et al., 2013), including the interplay of social circumstances and access to technologies (Schmidt, 2019). New forms of learning are examined, as makerspaces provide settings to engage with a broader community than spaces of formal education (Geser et al., 2019; Hennelly et al., 2019; Schmidt, 2019). Further, makerspaces are investigated as sites for new forms of work, with studies ranging from production, marketing, and sales executed without the organizational setting of a firm (Schmidt, 2019), to the governance structures of

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makerspaces (Ostrom, 1990, 2009), to collaborative work being assessed in its capacity to address present and future challenges by promoting autonomy of the actors (Gangloff-Ziegler, 2009).

Research at the intersection of Social Sciences and Economics focuses on alternative economy models and innovation ecosystems with maker communities, facilitating entrepreneurship and innovation outside of universities or corporate spaces (J. Bardzell & Bardzell, 2013; Lindtner et al., 2016; Tanenbaum et al., 2013) and contributing to circular, sharing, green, or informal economies.

Epistemology, methodologies and methods

The cross-cutting values and localised practices of making can be approached as 'global assemblages' (Ong & Collier, 2004), providing epistemological and methodological tools to account for heterogeneous aspects of making (Lindtner et al., 2016). The study of makerspaces is rooted in constructivist approaches, as they emphasize interaction, participation and experiential knowledge, thus promoting empowerment and emancipation, with the aim of social transformation for greater equity and social justice (e.g. Peterson & Scharber, 2017). Feminist approaches have also found strong attention, envisioning spaces which offer both safety and a platform for political resistance (Toupin, 2014).

Empowering communities to be creative and autonomous in solving relevant problems, in a horizontal, bottom-up learning process is the key motivation driving makers (Keulartz & van den Belt, 2016). Tinkering, trying out, failing are acknowledged steps towards improving, with context-specific social impact as the final goal, making the process of making an end and a means. As Bean & Rosner put it, 'those describing the maker movement tend to focus not on the material consequences of a 3D-printed plastic whistle, but rather on the broader social changes their practice promises to bring about' (2014).

Making as a practice is directed towards solving relevant local challenges autonomously. Often making is characterized by the creative and collaborative use of available means. Practices range from the reverse engineering and assembling of products by using low-cost or broken electronics and raw

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materials to the employment of emerging technologies (Bean & Rosner, 2014). Whilst makerspaces are often associated with groups of higher educated tinkerers appropriating technology such as 3D printers and laser cutters, zooming out we will find a rich culture of making, expressed through practices of repairing, improvisation, maintaining, and innovating (Butoliya, 2018). The scope of making can be observed in its creation, use, and adaptation of open designs across makerspaces around the globe. Generally, maker culture embraces learning-by-doing, trial-and-error approaches and informal peer-to-peer learning. All activities adopt a hands-on approach whereby learning emerges as the consequence of in-person engagement (Rosa et al., 2018).

Peer-production combines three core characteristics: (a) decentralization of conception and execution of problems and solutions, (b) harnessing diverse motivations, and (c) separation of governance and management of property and contract (Benkler, 2016). Rather than efficiency, profit and competitiveness, the central tenet of peer production is one of collaboration and mutual cooperation (Kostakis et al., 2015; Troxler, 2010, 2013).

Local and cultural appropriation of technology is a way to foreground the particular uses that an individual or group may make of goods, tools or objects. Bar et al. (2016) distinguish three modes of technology appropriation: Baroquization is the filling-in of technological spaces that providers intentionally leave blank for users to personalize; creolization is bricolage, the recombination of the technology's components to create something new; and cannibalism is creative destruction, breaking down the existing to invent something new.

Ideation is an iterative means of projecting through inspiration enabling processes in which makers can express themselves creatively and generate new ideas (e.g. Barrett et al., 2015; Beyers, 2010; Galaleldin et al., 2017; Longo et al., 2017). It is promoted by both the community infrastructure and the prototyping infrastructure (Böhmer et al., 2015; Farritor, 2017; Martin, 2015).

Concept iteration / prototyping mostly consists of four steps, i.e. build, test, feedback, revise (Cooper, 2017). A prototype is developed to be tested in iteration cycles. The diverse community of

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makerspaces constitutes a huge benefit in testing and feedback stages (Barrett et al., 2015b; Chu et al., 2017; Cohen et al., 2017; Galaleldin et al., 2017b; Holm, 2015).

Degree of and measures for participation

Normatively, makerspaces and their actors strive for shared ownership and agency. The co-creative and open sharing ethos of the maker community supports this ambition. A meaningful point of departure to investigate degrees of actual participation is the acknowledgment that openness in making is situated and multi-dimensional (Ahmadi et al., 2019; Ames et al., 2018; Green & Kirk, 2018). While the ethos of the maker movement calls for diversity, not all makers and makerspace managers take explicit efforts to include marginalized groups, such as women, people of colour, people with special needs, or the elderly (Rajapakse et al., 2014; Somanath et al., 2017; Taylor et al., 2017). This is one area in which CSS offers a starting point to develop situated explicit interventions for inclusion and diversity.

Social impact and measurement

The values and practices of combining executive and normative approaches and thus have the potential to redefine power dynamics within societies (Kera, 2014). Practices are stewarded through the makers' values. Makerspaces further contribute to the democratization of science by making otherwise withheld infrastructures and tools accessible and relevant to the wider public (Anderson, 2012; Bilandzic & Foth, 2013; Hennelly et al., 2019; Irie et al., 2019). They can be autonomous, anti-capitalist and counter-cultural places (Bouvier-Patron, 2015; Goldenberg, 2014) with projects targeting societal challenges, such as sustainability through up-cycling (Schmidt, 2019). The maker movement creates equity and contributes to the democratization of learning as it challenges and substitutes traditional pedagogical methods with more hands-on inquiry-based practices (Schad & Jones, 2020).

Strengthening the science-society bridge is rooted in makerspaces serving as environments for research and innovation liberated from disciplinary silos but actively bringing people from different

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disciplines and backgrounds together in the act of making. The significance of social impact is further enshrined in that making, in the maker culture, means sharing. Everything is made openly and freely available, ideas, innovations, codes, etc. are shared for appropriation.

Contribution to a Citizen Social Science methodology

Values central to the maker movement can be perceived as foundational pillars relevant to the shaping of a CSS methodology, too: (1) *Openness*: Makerspaces provide access to powerful, and partially expensive tools and they provide a community of peer learners (Ahmadi et al., 2019; Geser et al., 2019; Halbinger, 2018). (2) *Sharing*: Makerspaces hold altruistic values of open and reciprocal knowledge sharing, understanding knowledge as a public asset, as a commons (Johns & Hall, 2020). It includes sharing ideas through collaboration and sharing knowledge through mentorship (Irie et al., 2019). (3) *Inclusion*: Makerspaces are places open to all, indifferent to social status. They are promoting accessibility for people with diverse capacities to engage (Johns & Hall, 2020). The maker ethos seeks to not discriminate between perceived experts and laymen (Bilandzic & Foth, 2013; Brady et al., 2014).

Makerspaces, the practice of making, and the values underlying the maker movement offer valuable approaches on how to advance CSS, particularly in an increasingly digitized world. We can extract four key trajectories:

(1) *Openness and inclusion as enacted practice versus vision*: A CSS approach would benefit from explicitly outlining enactable practices/methods with the aim of enabling openness and inclusion in any context. This also relates to addressing all potentially discriminating factors in regard to spaces, methods, etc. An open sharing culture, continuously sharing methods, outcomes, and learnings with the wider community would be a desirable practice.

(2) *Putting societal impact at the centre of participatory processes:* A CSS approach would benefit from adapting a methodological frame based on impact orientation and continuous critical

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self-reflection. CSS can learn from the maker movements' struggle with biases regarding disadvantaged groups, techno-centrism, etc. and its self-critical response.

(3) *Building and benefiting a collective identity across diverse cultures and other contexts:* A CSS approach would actively and horizontally engage different disciplines and actors from diverse contexts into the process of shaping the methodology. Scholars, practitioners, and non-experts should have equal stakes, agency, and ownership in the process by design.

(4) *Civic spaces as places of identity formation and safety in the digital era, outside of institutional walls:* A CSS approach would benefit from acknowledging the relevance of third spaces in its methodology. Moving CSS outside of academic and corporate walls, into everyday societal spaces, may prove key in enabling true participation and inclusion.

Critical points

Many maker activities are built around workshop formats, utilizing participatory action research as a proven method. However, sustainable community building and long-term effects do require more regular and continuous practices (Ahmadi et al., 2019). Digital utopianism and techno-solutionism are potential blind spots of the maker movement (Lindtner et al., 2016), as is its commodification and co-optation by the corporate system that makers set out to disrupt (Avle et al., 2017; Irani, 2015; Toombs et al., 2015). Exclusion of people based on their gender, ethnicity, age, geographical location or socioeconomic status, and the related contradictions between rhetoric and reality in the maker movement have equally received critical attention (Ames et al., 2014; Britton, 2015; Lewis, 2015). Connected to this is the lack of sufficient, accessible documentation which would be a prerequisite to truly open sharing (Au Yeung et al., 2018; Bonvoisin et al., 2017).

4.3.6.Co-Evaluation

Historical background and description

Co-evaluation is a form of participatory evaluation that initiates the conversation on expectations, objectives and impact at the start of the project, when the research design is co-created with different

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stakeholders, or when the participation of actors is negotiated. Whenever possible, this conversation is extended beyond the project end, to discuss and assess the manifold types of impact of a collaboration (a project, a program, creation of an institution). Participatory evaluation is deeply rooted in international community development since the 1960s with the growing attention to multiple perspectives in decision making (King et al., 2007). Precursors include emancipatory and action-oriented research and community education in the 1970s (Chouinard & Cousins, 2015). As a concept it goes beyond the assessment of research output and scientific quality to generate more insights about the broader impact of either publicly funded research or potentially risky technology dating back to the 1980s and 1990s (Williams & Grant, 2018). The systematic assessment of policy programs – not only for scientific research – gave rise to question common roles and functions of social inquiry and of social inquirers. In the focus came the often-neglected expertise and knowledge of the participants of social research, and with it the need for democratic pluralism. In line with (Cousins & Whitmore, 1998) Brisolara suggests to differentiate along a continuum of types of participatory evaluation: one the one hand practical, utilisation within the status quo oriented evaluation, and on the other hand action-oriented, ideological, participatory evaluation (Brisolara, 1998). Co-evaluation takes a transformative stance, as it includes co-creation methods that aim not only at learning about a situation but also at overcoming hindrances and finding solutions to problems, such as how to measure the success of a research project in terms of stakeholder benefits.

Scientific fields and epistemologies

In the body of literature on citizen science, evaluation is discussed rather at the margins, however the debate on quality criteria and characteristics of citizen science is still hot in 2020 (Auerbach et al., 2019; Haklay et al., 2020; Heigl et al., 2019a, 2019b). Literature on Citizen Social Science is sparse, among the output there, evaluation is rarely discussed (Mayer et al., 2020). We find increasing interest in the topic and see more publications featuring reflections of the processes and instruments applied (Follett & Strezov, 2015). Bridging the current debate on quality (Kieslinger et al., 2017) with attempts to assess citizen science projects across methods and types of intervention (Home & Rump,

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2015), helps to integrate insights from community-based participatory research, participatory learning and action (Bozalek & Biersteker, 2010), participatory monitoring and evaluation (Cousins & Whitmore, 1998; Estrella & Gaventa, 1998). The combination of experiential learning with critical reflection of socio-political and cultural relations and assumptions deeply embedded in processes of social change, provides a robust basis for inclusive evaluation procedures. Furthermore, co-creation processes require some sort of coordination and expectation management as well as attention to the community building processes (Gouillart, 2012). In such processes, different normative regimes need to be aligned that benefits for all participants are considered in a balanced way. Evaluation procedures therefore must consider not only the expectations towards the results and benefits, but also the expectations towards the ways knowledge is produced – towards the epistemologies. Anticipation of such expectations is also called for in the concept of responsible research and innovation RRI (Owen et al., 2012).

Degree of - and measures for participation

Typically, measuring the success of scientific projects is realised with predefined indicators, such as cost-benefit efficiency, bibliometric assessment, number of patents and so forth. The wider outcomes and social impact, however, are much more difficult to measure. For example, the degree of participation and involvement of research participants, or the un/intended changes in practices or policies, the potential to reach the sustainable development goals, all those need to consider various contexts (Whitmore, 2001). Instead of proposing a set of predefined methods, co-evaluation builds rather on a set of principles and is aiming to adapt to the situative contexts.

By today, participatory research is exploring evaluation approaches to accommodate the diversity of perspectives of research stakeholders (Springett, 2017). In the case of a citizen science project evaluation, it is therefore necessary to focus not only on the scientific outcomes, but also on the different motivations and expectations in regard to the socio-ecological and economic dimension both of the process and the outcome, as well as on the impact in those dimensions. Of particular

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importance in that regard is the "growing push for new ways of defining and measuring success" (Moschetti, 2003, 18) of participation. Exploring the changes brought about by an intervention requires a robust set of measures for success (including targets and methods to measure and discuss them) that could be co-created at the beginning of the project and dynamically developed further throughout the project.

The Citizen Science Evaluation Framework by Kieslinger et al. (2017) brings together insights on process and outcome to combine formative and summative evaluation: formative input serves for an adaptive project design, summative evaluation brings evidence of a project's benefits to its participants and their surrounding contexts. Design and prioritization of indicators (quantitative and qualitative) should be adapted to the project context and specific objectives.

Social impact and measurement

We have to be aware that the core aim of Citizen Social Science is performing citizen science for social change. Therefore, the parameters applied should be suited to measuring improvements in quality of life or the social quality of policy and governance next to the more traditional indicators of citizen science, such as the scientific impact or the learning outcomes of the participating individuals. With regard to impact assessment, this means gathering evidence for change in environments, which are highly dynamic, and therefore unpredictable. Co-evaluation requires a steady stream of information to understand what is happening and what are the effects, so that stakeholders are provided with ongoing opportunities to learn from feedback.

Contribution to CSS methodology

Co-evaluation is defined as a process that involves all relevant actors in a project in an iterative evaluation practice and combines methods of participatory action research for evaluation purposes. Co-evaluation does not only help to assess the participatory aspects of citizen social science, it also does so by participation. Project goals, understanding of success, challenges and unintended aspects are collectively discussed and documented at the beginning of a project and regularly re-visited

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during the research design and execution, ideally even beyond the project's end. Assessment and intended impacts hence become transparent entities in the project design and important elements of the research tools inventory. Co-evaluation hence means making citizens and project participants part of the project evaluation by involving them in the definition of objectives and jointly decide and develop the most suited measures to assess the project process, results, and impact. Co-evaluation is rather a way of working together based on a set of principles than a rigid set of methods, it therefore blends perfectly into citizen social science methodology.

The most important contribution of co-evaluation to CSS methodology is the option to co-develop suitable instruments for engaging with motivational factors and managing expectations in the assessment of social impact. In order not to generate too much effort, participants are equipped with the appropriate tools and guided by prior identified foci as well as moderators in individual or collective formats, such as group discussions, collective mapping, or generative online platforms, scrapbooks, graffiti boards to improve theatre (Springett & Wallerstein, 2003).

Critical points

Co-evaluation schemes need to be assembled according to the project goals and the participants' expectations, but also flexibly meet changes in the dynamics of participatory research routines. The challenge is to plan accordingly, develop the necessary skills and incentive structures for such inclusive evaluation settings, so that assessment is actively implemented from the beginning of the research design. As outlined by Schäfer et al. (2020) participation in evaluation is not easy, it is time consuming and needs specific expertise for the evaluation task. Evaluation methods that focus on the investigation of changes on individual participants have been developed and made available, enabling comparisons across an increasing number of projects. But the evaluation of outcomes that affect

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whole regions, communities and socio-ecological systems is an even more complex task. Thus, we currently see that there is a call for the further development, sharing and uptake of standardized, easy-to-use and proven evaluation instruments that go beyond impacts on individuals. Such instruments could benefit both, project owners, research stakeholders as well as the citizen science community overall and would allow for a deeper understanding of different contexts that influence the changes in individuals, communities and regions.

5. Findings for further developing Citizen Social Science

In Chapter 4 we have discussed our three different points of departure for CSS research focussing on selected methodologies, methods and approaches as well as experiences from CSO-led research. The aim was to identify fundamental components for the application in our R&I Actions, which will then be tested and further developed towards a CSS methodological framework in the coming years of the project. In our review, we have put focus on historical backgrounds, scientific fields, epistemological and methodological foundations, participation, social impact in order to point out contributions to a CSS methodology as well as critical points and blind spots. In this chapter, we summarize and process these findings to extract tools, methodologies and approaches for applying in the R&I Actions and crucial topics and strategies that need to be discussed for further shaping a sound CSS approach.

In the following, we *first* summarize underlaying foundations and (meta-)theories of the candidates discussed in the previous chapter (Chap. 5.1). *Second,* we are gathering potential tools to work with in the R&I Actions that have been detected during the review (Chap. 5.2). *Third*, we assemble challenges that we subsequently would have to address as we move forward with the shaping of a CSS framework (Chap. 5.3). Last, but not least, we point out a selection of 8 crucial topics that would need further attention in the R&I Actions and which we consider substantial for a CSS methodological framework (Chap. 5.4).

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5.1. Foundations

In state-of-the-art review we found that discussions of epistemological and methodological foundations of a CSS framework are rather exceptional and occur only in papers and projects that locate themselves explicitly within CS. Thus, identifying and critically assessing genuine overarching principles of CSS in the further course of CoAct indicate crucial steps towards creating a sound framework that gathers all those different approaches and its various epistemologies.

As we have seen during our review in the previous chapters, the theoretical and methodological references of CSS are manifold. The review shows a vast variety of social science theories applied in the discussed approaches, methodologies and methods: participation and urban governance (Arnstein, 1969); structuration theory (Giddens, 1984); theories of change and realistic evaluation (Blamey & Mackenzie, 2016); computational social science and data-driven science that builds data-driven mathematical models (Conte et al., 2012; Lazer et al., 2009); community-based participatory research (Israel et al., 2008; Arxer & Murphy, 2018); game theory, theories of problem solving and organizational theories (Scheliga et al., 2018; Prpić & Shukla, 2014; Dickinson & Crain, 2014), global assemblages (Ong & Collier, 2004), feminist approaches (Harding, 2004; Toupin, 2014), sharing culture (Hatch, 2014), behavioural sciences (Gutiérrez-Roig et al., 2016), postcolonial theories (Spivak, 1988) and decolonial theories (Anzadúa, 1987), critical geography (Santos, 1978), public sociology (Burawoy, 2006), local and indigenous epistemologies (Wicks et al., 2008; Pyrch & Castillo, 2001).

The epistemological foundations indicate a central intention to direct CSS towards contributing to social impact and sustainable change. This intention is predominantly rooted in discourses about research and innovation as well as transdisciplinary and transformative science. Moreover, we have identified a variety of action repertoires from diverse civic and disciplinary communities that represent forms of civic engagement towards social change. Examples range from the maker community, finding its roots in the open software movement, to data activist practices applying rigorous bottom-up data practices for the creation of methodologically sounds evidence through self-empowering research.

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All selected methodologies, methods and approaches share, whereas in different notions, a dedication to (Fig. 15): (1) transdisciplinarity as an inclusionary approach directed to different stakeholders to improve the evidence-base; (2) active participation and co-creation of citizens to connect the research with the citizens' concerns; (3) social change as an fundamental aim of the research; and on a more general level to; and (4) democratization of science regarding the means of research and the research results.

Figure 15: Shared ground of the different methodologies, methods and approaches

Albeit, the state of the art indicates a strong implicit argument for different forms of participation throughout the selected candidates, often there are no explicit reflections on specific concepts of power relations. However, the connection of participation as a key concept in relation to power structures would need further attention. This debate touches upon the roles of different stakeholders and especially of the citizens involved in the research, questions of agency and finally the

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democratization of science. Here a deeper analysis with theoretical end epistemological references mentioned above would contribute to the practical and methodological further development of CSS. I.e. discussing existing concepts of participation, inclusion, social impact and social change in preparation for and during the R&I Actions would enable connections to the academic discourse, on the one hand, and holds also potential for improving practical applicability and the impact of the research towards change, on the other hand.

A general theoretical hypothesis for CSS extracted from the review that could be tested in CoAct would be the following: If citizens are involved in conducting research about their own social lifeworld, they must have a say, in both, the research-based definition of social reality and the planning of social actions that affect them. Thus, participation is connected to higher social impact. Moreover, central dimensions of CS, like inclusion, contribution, and reciprocity, must be supplemented with further concepts such as responsibility, transparency, and mutual trust (Owen et al., 2012; Smallman, 2018). In this way, it is possible to achieve closeness to the lifeworld and practical relevance, a focus on problem solutions, and concrete answers – in other words, an orientation toward citizens' lived reality. This opens up the prospect that the research process will produce 'socially robust knowledge' (Gibbons et al., 1994; Nowotny, 2003) and that citizen scientists will be taken seriously and included as equals in the substantive development of the research process and, moreover, as contributors in policy making (Maasen & Lieven, 2006).

5.2. Tools

As we have already seen in the previous chapters, there is only partially shared epistemological ground among the selected candidate methodologies, methods, approaches and practices of the three different streams of CSS. Nevertheless, we see much potential for mutual learning between CS, the Social Sciences, and research initiated and led by citizens in a truly transdisciplinary manner. We identified a multiplicity of potential tools for CSS research (see Table 3). This selection of tools deriving from the different methodologies, methods and approaches marks another step towards the further

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development of an overarching CSS methodological framework. Each of the potential tools provides potential for a practical application and exploration in the R&I Actions.

PAR	▪ participatory methodological framework for transdisciplinary research ▪ Research Forum as foundational communicative spaces for all stakeholders ▪ decentring social reality and social actions in everyday life
INCLUSIVE RESEARCH	▪ co-created research on equal footing ▪ sensitivity for diverse backgrounds and inclusion of marginalized people ▪ potential to decentre and change (social) science as a whole
COMPSS	▪ holistic perspective of social phenomenon enhances public understanding ▪ 'Complex system approach for transdisciplinary non-compartmental knowledge production ▪ data-driven mathematical modelling to identify fundamental elements and to understand how they interacts
REAL-WORLD LABS	▪ low-threshold participative experiments ▪ interventionist impact on everyday practices and policy making ▪ Theory of change to identify steps to achieve long-term goals
ART-BASED COLLECTIVE MAPPING	▪ participatory methods and co-creation of knowledge ▪ connection between co-creation and visual tools through artistic practices ▪ connection to social activism and practical tools promotes social and political transformations
CSO-LED CITIZEN SCIENCE	▪ bridging gap between academic, civic and political discourses ▪ identification of pressing social problems by promoting sustainable social change ▪ (self-)empowerment, collective identity and coalition building
OPEN SCIENCE	▪ access to scientific knowledge via online repositories ▪ collective creation of knowledge commons and shared resources ▪ open data and methods for improvement of accountability, testing and replication of results, as well as evidence-based decision making
CROWD SCIENCE	▪ big data analytics from the aggregation of individual contributions ▪ pre-existing technical and organizational infrastructure ▪ attract large numbers of citizens with low-threshold and high potential of science literacy with simple actions
CITIZEN GENERATED DATA	▪ trustworthiness, accuracy, reliability and representativity serving as data quality factors ▪ appropriate and sufficient trainings as a prerequisite ▪ deliver baseline research and increasing the granularity of existing data
HACKTHONS	▪ transdisciplinary collaboration on complex problems ▪ creation of new ideas, tools and prototypes in a short period of time ▪ high potential for rapid social impacts and open and transparent practices and results
MAKER SPACES	▪ open and reciprocal tools for knowledge sharing and knowledge commons ▪ inclusive civic spaces open to all people regardless of social status outside of institutional walls ▪ societal impact at the centre of participatory processes and collective identity building

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CO-EVALUATION	▪ co-creation of instruments to collect motivational factors, expectations, social impact ▪ collective discussion and representation of project goals and objectives, success, challenges during the project, as well as project results ▪ transparency of the project design and important elements of the research tools inventory

Table 3: Tools for Citizen Social Science

5.3. Challenges

Beyond these potential tools the different methodologies, methods and approaches also include challenging aspects that have been raised during the review. A collection of what we can learn from challenges faced in previous research for our R&I Actions and for further developing a CSS methodological framework is described in Table 4. In general, some approaches point towards reflecting and challenging power disbalances and dynamics as well exclusionary aspects regarding the research design. Whereas other approaches emphasize more aspects of data and research results, like quality, legitimacy, openness and up-scaling as well as the commodification or co-optation. Thus, the different approaches of CS, Social Sciences and CSO-led research can combine theoretical, technical and real-world expertise to deal with such challenging topics in CSS research as we point out further below (see Chap. 5.4).

PAR	▪ relevance of local results and up-scaling ▪ power disbalances
INCLUSIVE RESEARCH	▪ diffuse concepts of inclusion, pseudo-inclusion ▪ tendency towards normalization ▪ multiple oppression hinders inclusion
COMPSS	▪ top-down structures restrict degree of citizens engagement ▪ handling of sensitive data
REAL-WORLD LABS	• top-down structure of experimental research settings restricts participation ▪ positivistic methodology reduces the potential of co-creation ▪ lack of indicators for measuring outcome
ART-BASED COLLECTIVE MAPPING	▪ standardisation difficult ▪ poor social impact measurement ▪ tension in dialogue with policymakers
CSO-LED CITIZEN SCIENCE	▪ deepening existing inequalities ▪ little collective experience of working within a scientific research process ▪ collaborative interpretation of results

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OPEN SCIENCE	▪ degree of openness and participation ▪ openness as threat for people in exposed or marginalised positions ▪ lack of merit and prestige
CROWD SCIENCE	▪ lack of inclusion in research co-design ▪ accessibility of data, and results ▪ neoliberal governance and exploitation
CITIZEN GENERATED DATA	▪ data collection activity risky or illegal ▪ no complementarity with official data sources ▪ different capacities, priorities, values, or responsibilities of stakeholders
HACKTHONS	▪ lack of diversity of participants ▪ creation of prototypes only created for the hackathon ▪ licensing and intellectual property issues
MAKER SPACES	▪ methods may lack long-term effects ▪ commodification and co-optation ▪ lack of sufficient, accessible documentation
CO-EVALUATION	▪ co-evaluation schemes alignment with project goals, expectations, capacities ▪ preparation and planning overload ▪ evaluation of outcomes after project end

Table 4: Challenges for Citizen Social Science

5.4. Crucial topics for further discussions

Taking the potential tools as well as the various challenges into consideration, in the following, a selection of 8 crucial topics for further discussion and development are pointed out. Regarding the R&I Actions these crucial topics also include strategies which constitute potential starting points for deepening the reflection and sensitivity for certain critical aspects of CSS that emerge from the literature review and previous research project's experiences.

5.4.1. Engagement, collaboration and cooperation: Co-Researchers

Whereas participation is one of the key elements of CSS, we found not one homogeneous definition but rather different notions of participation. For further developing CSS, the specific levels of participation in each research need clarification. Initially, we would need to ask, what could be the practical implications of engaging 'Co-Researchers' in the research in contrast to rather passive notions of 'volunteers' or 'participants'. Together with the Co-Researchers the potential of CSS to include knowledge and perspective of citizens in the different phases of the research needs to be explored, i.e. including the collective interpretation of data and presentation of research results. Moreover, not all Co-Researchers like the term 'participation' itself. Thus, alternative terms and

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notions would be to agree on, i.e. cooperation, collaboration or engagement. It seems essential to keep discussions regarding the interests of the different stakeholders open and going, identify common ground and goals as well as inclusionary potentials. Crucial questions that would need further discussion are the following: How do we frame participation and how do we shape it within the notion of CSS? What are the consequences while engaging with different communities in shaping this crucial concept? How much participation is necessary and useful in a specific context and in which phases of the research? Who is in charge for what and why?

5.4.2. Increasing social impact and social change

Social impact – as another key element of CSS – also appears as a rather blurry concept that addresses different dimensions in its various notions. With CSS aiming to maximise a social impact within and through the research, this requires an ongoing reflection of innovative ways to enhance public debate and dialogues, and to approach citizen concerns to those bodies responsible of delivering policies in at least local, regional and national levels. Long-term effects of the research as well as the up-scaling of results need to be tackled. This ambition touches upon the following questions: Who could be included in the Knowledge Coalition? What formats could be used to publicly discuss and present the research? Which analogue and technological tools and platforms could be used for the outreach and dissemination of results? Furthermore, we have to ask the crucial question: Social impact for whom and regarding what?

5.4.3. Developing a theory of change

Developing a theory of change seems promising for clarifying the goals of the research. Most of the approaches include emancipative and transformative aspirations and are connected to social activism or political campaigns. But at the same time, they lack a specific method to specify what the aspired change would be. Against this background, a theory of change identifies long-term goals which in reverse could help shaping the repertoires of action and knowledge production towards mapping necessary preconditions to improve the actual impact for achieving the goal. Developing a theory of

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change in a Knowledge Coalition would also provide a potential tool for capacity and community building among the different stakeholders of the research. What is the goal that we want to achieve? Which steps are to be taken for achieving the goal?

5.4.4. Impact measurement

Even though social impact is a central aspect of CSS the actual tools for its measurement are currently less developed or generally absent. Therefore, co-evaluation and impact evaluation need much more attention and further development in the R&I Actions for tackling this major blind spot in order to improve gathering evidence in CSS. Thus, a complementary mix of evaluation methods is required. Ideally, these different types and formats need to be implemented from the very beginning of any research activity, starting with citizen engagement activities and awareness measures. Furthermore, intended effects, such as increased empowerment, improved sustainability, better data, etc. must be described early in the research design and must be measured not only during the ongoing project, but also after the project end. This will require creative solutions, as well as the involvement of communities and distributed ownership of the processes developed.

5.4.5. Quality of research results

As another critical point the legitimacy of the research results of CSS research has been pointed out. We found that CS practices are in numerous cases not accepted as a valid methodology in their related scientific disciplines. Thus, research papers have sometimes trouble to be published in peer-reviewed journals and also presented research results have not been recognized by political decision makers. Strategies to tackle this suspicion would include a rigours empirical methodology valid for the professional researchers and co-researchers. Moreover, strategies for lobbying for co-designed and co-created CSS could be discussed together in the knowledge coalition. This would include emphasizing the potentials of the role of co-researchers beyond ‘data providers’. Therefore, potentials for enhancing the quality of research results concerning real-world problems through CSS could be further emphasized. The quality of CSS research is to meet the needs of both sides – the co-

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researchers' generally need for practice-relevant forms of knowledge corresponding with local contexts, while the researchers' generally need for generalized empirical insights and findings.

5.4.6. Increasing inclusiveness, accessibility and applicability

Inclusiveness, accessibility and applicability as further key characteristics of CSS need also ongoing reflection and clarification throughout the whole research process – especially regarding comprehensiveness and science literacy. First and foremost, higher degrees of inclusion can be reached by using plain language and avoiding technical language as well as jargon whenever possible while maintaining rigour and accuracy and, moreover, through transparency in the documentation of meetings to avoid misunderstanding. Moreover, visualizations of social phenomenon and research results have affective power and support inclusive, accessibility and applicability effects. Also, openness, transparency and low-threshold and ready to use methods would need ongoing reflection for strategic adaption during the different phases of the R&I Actions. At this point, the 'FAIR' principles – findability, accessibility, interoperability and reusability of non-sensitive data – deriving from OS would provide a potential framework for improving the inclusiveness and the impact of the research. Moreover, ongoing reach-out actions in different formats could help to engage co-researchers beyond a particular activist community. A basic question would be: How to enable context driven approaches that assure inclusiveness and accessibility are truly deriving from each individual case specific context (political, infrastructural, cultural, etc.)?

5.4.7. Agency, resources, ownership

Agency as another core concept needs to be discussed in relation to participation and actual engagement of Co-Researchers in the R&I Actions. Inclusion effects of the research could be enhanced by an open debate in the research coalitions of questions like: 'Who is taking responsibility for what? Who is representing whom and why?' As we have seen, discussions about ambivalences of CS as part of a neoliberalization in science are still the exception today. A critical debate about cheap, alienated labour in a competitive, neoliberal research environment to counter-balance state

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responsibilities could fostering the (self-)empowering aspects of CSS. However, as co-evaluation expertise shows, commitment comes with ownership. Thus, questions of ownership, recognition systems and compensation of participants would need to be discussed further. For CSS research aiming for a high degree of participation of Co-Researchers, it seems essential to provide at least, to open a dialogue on this topic. Most of the time, various forms of immaterial compensations are provided during the different research phases, such as knowledge exchange and mutual learning. Moreover, having co-ownership of the research results as well as gaining social visibility are alternative compensational approaches to financial forms. One strategy to achieve, would be to include co-evaluation in R&I Actions from the beginning.

5.4.8.Safe communicative space and power relations

As the different levels of participation and compensation are constituting a certain hierarchy in the research, open conversations between the different stakeholders of the research would be one key element. Moreover, different communicative skills and competencies are constituting power-relations within a certain communicative space. CSS brings heterogeneous actors (academics, citizen scientists, political decision makers, among others) to the table in communicative practices and thus needs to cope with and bridge between different interests this double bind of structural and communicational hierarchies. In consequence, a conceptualized safe and open space for communication, reflection, planning and mutual learning for all research participants would constitute a prerequisite for CSS. Not only are constant reflections of power relations and the provision of an open conversation space during the research a challenging intend but, in fact, essential steps at once towards a collaborative knowledge production. A moderated open and safe communicative space would provide the framework for addressing critical points as well as positive aspirations of the co-creational processes. The conceptualization and practical implementation of such a communicative space would need to adapt the specific research context and questions but it can share similar methodologies among the R&I Actions.

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In CoAct, we follow the principals of RRI (e.g. Owen et al., 2012; Smallmann; 2018). With social issues and social actors in the centre of the research, the ongoing discussion, adjustment and clarification of research ethics are an essential backbone of the R&I Actions and further of a CSS methodology. Informed consent is already being identified as a critical tool in this methodology. It needs to be fully understandable by any participant and it will also need to be adaptive to co-creation dynamics. Finally, another relevant aspect will be to balance the Open Science principles with privacy of participants. Personal data disclosure could indeed, in our R&I Actions lead to increase vulnerability of participants in the context of Mental Health, Youth Employment, and Environmental Justice.

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6. Appendix

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Network analysis procedure

We briefly explain the process step-by-step in preparation for the Network analysis that we present in Chapter 3.3:

(1) We take the public folder 'State of the Art Report' of the 'Citizen Social Science' collection that the consortium members have uploaded at Zotero. In total, there are 630 bibliographical references.
(2) The key elements from the database are the title, the abstract and the publication year.
(3) With the dataset, we proceed to perform two different kinds of analysis: (a) The most used words and (b) the relationship between references through the terms they share.
(4) Most used words are analysed in terms of the rank-frequency distribution. This is a standard analysis in the field of computational linguistics, which usually takes as reference Zipf's law.
(5) A network analysis has been used to study the relationship between the references. VOSViewer software is been used. The open software offers a text mining functionality that allows to construct and visualize co-occurrence networks of terms extracted from a body of scientific literature.

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(6) Those references written in German or Spanish (not English) have been included in the analysis by translating to English their abstracts. VOSviewer software only supports English.

Review methods

For determining our review strategy in preparation of the report, we consulted papers that discuss scoping methods and literature reviews on CS (Kasperowski & Kullenberg, 2019; da Silva, Heaton & Millerand, 2017; Conrad & Hilchey, 2011; Suomela & Johns, 2012; Tauginienė et al., 2020). Since these studies have been rather specialized, we have additionally looked at review strategies in other disciplines that aim for an exhaustive exploration of a certain scientific field (Arksey & O'Malley, 2005; Ehrich et al., 2002; McBride, 2020; Peters et al., 2015). In the following we describe our selection criteria, search and selection procedures for papers to review was well as our thematical analysis and critical interpretation of the papers regarding the candidate methodologies, methods and approaches of which we compiled Chapter 4.

Selection criteria

As a starting point, five inclusion/exclusion criteria (Peters et al., 2015; Sperka & Enright, 2017) for papers to be included in the review were defined s based on the review questions stated above (see also Chap. 1. Papers that have been included had to: (1) address social issues; (2) involve participation of citizens; (3) be published in a peer-review academic journal or via acknowledged CS channels; (4) be written in English, German, Spanish; and (5) be published between 1995 and 2020.

Criteria (1) marks an inclusive criterion towards a wide and open definition of CSS. It puts focus on papers addressing social topics in the wide field of CS research. *Criteria (2)* constitutes another inclusionary criterion that puts focus on citizens' participation in the research process of CSS. We focused on the actual involvement of citizens during the different research phases (Arnstein, 1969; Bonney et al., 2009). *Criteria (3)* seeks to guarantee the scientific quality of the papers included in this

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review. Clear cut criteria to determine if a CS channel is scholarly acknowledged, were not easy to define. Therefore, the selection was based on our judgement towards known projects and recognized scholars involved and present in these channels. *Criteria (4)* is related to the R&I Actions in order to connect with the contextuality and with corresponding discourses in the four countries. *Criteria (5)* sets a starting point for our CSS review in 1995 with Alan Irwin's influential book 'Citizen Science' that has been one of the first publications addressing this new emerging approach. Notably, it was already connected with our focus on social issues, participatory approaches and social science methodology, even though the term CSS itself was coined much later and became an emerging topic in the CS community only recently. In order to include the latest publications, the final search was carried out in May 2020. All these criteria helped processing the review questions and thus necessarily limited the scope of the review.

Search and selection procedures

As a starting point, all consortium partners contributed to a list of CSS related papers. A distinction of own papers, most influential papers for the research group, and the most underestimated papers was made to take directly into account the researchers' domains of expertise (McFerran, Garrido & Saarikallio, 2013). At the same time, two databases were searched regarding the candidate methodologies, methods and approaches to identify further papers of interest: Web of Science and Scopus. At this early stage, the goal was to explore all possible scientific fields and to collect literature as wide as possible. Furthermore, the bibliographies of most recent papers were searched for literature that was not retrieved during database searches. In a last step of the selection procedure, the abstracts – if necessary, the full text – of the compiled papers in the shared bibliography-database (Zotero) were screened against the inclusion/exclusion criteria (see above). At the end a collection of 236 papers have been identified as a basis for the review.

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Thematical analysis and critical interpretation

The thematical analysis and critical interpretation of the papers was carried out by following a four-stages approach: *First,* the papers were categorised and clustered regarding the different approaches, methodologies, methods they represent by going through the abstracts and the key words. As a result, eleven different candidate methodologies, methods and approaches have been identified and reviewed separately. We consider this selection contingent, since it was shaped by the perspectives and specific expertise of the CoAct consortium members.

Second, the review of each paper was focussing on: (a) article type and short description; (b) Scientific fields and topics; (c) epistemology, methodologies, methods; (d) degree of and measures for participation; (e) social impact and measurements; (f) contribution to a CSS methodology and (g) critical points and blind spots. For determining and assessing the degree of participation we applied the following classification: (1) *Contributory projects*, with citizen participation largely limited to contributing to data collection and recording; (2) *Collaborative projects*, with the involvement of citizens in data analysis and, possibly, interpretation; (3) *Co-created projects*, with citizen actively involved in most or all steps of the research circle; and (4) *Citizen-led projects*, with citizens in full control of the project design (Thomas, Scheller & Schröder, forthcoming).

Third, the key findings of the analysis constitute the main body of the review (Chap. 4). Each of the different subchapters discusses one candidate methodology, method or approach separately regarding: (a) historical background and short description; (b) scientific fields and topics; (c) epistemology, methodologies and methods; (d) degree of and measures for participation; (e) social impact and measurements; (f) contribution to a CSS methodology; (g) critical points and blind spots. Moreover, the Citizen-led Citizen Science perspective of two CSO consortium partners was included in a sperate chapter.

Fourth, by drawing on the findings of the review in Chap. 4 the separate reviews have been summarized and discussed following a meta-synthesis methodology (Paterson et al., 2001; Zimmer,

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2006) regarding: (a) the epistemological and theoretical foundations; (b) potential tools for CSS; (c) challenges of CSS; and (d) for critical topics for CSS to be discussed further (Chap. 5).

Endotes

1 https://en.wikipedia.org/wiki/Web_of_Science Information retrieved 26th of June 2020. Only considering WoS Core Collection.

2 https://www.vosviewer.com/

3 For more details, see the description of CoAct's Ethical Value at the project webpage: www.coactproject.eu/our-ethical-values/

4 The organization was recognized as one of the most important global environmental think tank by the University of Pennsylvania (https://farn.org.ar/archives/27459)

5 www.quepasariachuelo.org.ar.

6 www.youtube.com/watch?v=MybUS3VaMp8

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