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The status and potentials of citizen science: A mixed-method evaluation of the Danish citizen science landscape

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UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE – DEPARTMENT OF SCIENCE EDUCATION

The status and potentials of citizen science: A mixed-method evaluation of the Danish citizen science landscape

Master thesis

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Abstract

Citizen science is a rapidly expanding field of scientific inquiry, but the field of citizen science in Denmark has not been systematically reviewed. This study explores the status and potentials of citizen science in Denmark though a mixed-method review of the current landscape of citizen science projects and themes of interest among citizen science project developers. First, Danish citizen projects were identified and categorized according to established typologies. Secondly, interviews of citizen science project developers were performed and analyzed to reveal which themes shape the landscape of Danish citizen science. Thirdly, quantitative investigations were performed to reveal how citizen science involvement shapes citizen science-related attitudes and preferences.

A total of 55 running citizen science projects were identified, with the majority being *Investigation* or *Conservation* projects organized by science institutions or NGOs. In many projects, public participation was limited almost exclusively to data-collection. The thematic analyses of interview data revealed that organizational constraints, participation-patterns, data-quality and citizen science impact were vital themes of interest for assessing the status and potentials of citizen science in Denmark. The quantitative analyses supported these findings. Citizen science-related preferences among citizen science project developers varied significantly across organizational ties. This study shows that Danish citizen science is mostly an instrumentalist, top-down-facilitated, input-oriented entity, but the evidence suggest that citizen science is also widely the regarded to be capacity-building. It is discussed how perceptions of CS influence the status and potentials of CS in Denmark. Finally, this study discusses how the potentials of citizen science in terms of scientific impact and societal impact can be realized.

Resumé

Citizen science er et videnskabeligt koncept, der er under hastig udvikling, og som har potentialet til at have store videnskabelige- og samfundsmæssige implikationer. Dette studie undersøger gennem inddragelse af kvalitative og kvantitative metoder det danske øjebliksbillede ift. citizen science projekter samt de temaer og holdninger, der former citizen science i Danmark.

Først blev danske citizen science projekter systematisk identificeret og kategoriseret. Dernæst blev interviewdata indsamlet blandt personer der var professionelt involveret i citizen science projekter. Interviewdataen blev analyseret tematisk. Pba. den erhvervede viden om citizen science blev et spørgeskema udformet og distribueret blandt personer, der var professionelt involveret i citizen sci-

ence projekter. Ligeledes blev data indsamlet fra en referencegruppe. Den kvantitative data blev analyseret statistisk.

I alt 55 igangværende citizen science projekter blev identificeret og kategoriseret, hvoraf de fleste havde udgangspunkt i monitorering af økologiske mønstre. Den tematiske analyse af interviewdataen viste, at først og fremmest organisatoriske forhold, deltagelsesmønstre, datakvalitet og den videnskabelige -og samfundsmæssige effekt af citizen science var vigtige parametre for udviklere af citizen science projekter – og dermed essentielle for at evaluere citizen science' status i Danmark. De kvantitative analyser understøttede dette, og bemærkelsesværdigt var der statistisk signifikante forskelle i, hvordan respondenter fra forskellige organisationstyper betragtede citizen science og citizen science projekter.

Overordnet konkluderes det, at citizen science i Danmark gennemgående har en instrumentel, input-fokuseret karakter, men at billedet ikke er ensidigt, eftersom det var bredt anerkendt at citizen science kan have store positive indvirkninger på deltagernes læring, engagement og på samfundet som helhed. Afslutningsvist diskuteres det, hvordan citizen science projekter fremadrettet kan realisere de potentialer, som bl.a. dette studie har været med til at afdække forståelsen af.

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1. Introduction

Citizen science (CS hereafter) is a rapidly expanding field of scientific inquiry, yet CS is by no means a novel scientific entity. Throughout history, non-professional scientists such as Mendel, Darwin and Franklin have been essential to the creation of scientific results, methodologies and theories (Resnik et al. 2015; Eitzel et al. 2017; Kullenberg & Kasperowski 2016; Mason & Garbarino 2016; Bonney, Ballard, et al. 2009). As the scientific contributions of non-professional citizen scientists is indisputable, historically and present, the need for understanding the field of CS is ever pressing.

CS approaches have been applied to a multitude of sciences. However, namely the fields of ecology, astronomy, meteorology and history have been explored via CS approaches (Dickinson & Bonney 2012; Masters et al. 2016). The scientific and societal impacts of CS projects are recognized across sciences, contexts and countries. For instance, data from the American Zooniverse project has been used for more than 50 scientific articles in multiple fields of science (Bonney et al. 2014). In Denmark, the BirdLife Denmark coordinated project "Punkttællingsprogrammet" has provided empirical evidence and political leverage in nature policy decision-making since the 1970's (Dansk Ornitologisk Forening 2018c; Thomas Vikstrøm, personal communication). As CS is a rapidly developing field of scientific inquiry in Denmark and internationally, this study aims to review the landscape of Danish CS initiatives to understand how CS is integrated into scientific practices, policy-making, science communication and education in Denmark.

CS-based practises has also been conducted in interdisciplinary fields of science such as artificial intelligence, human health sciences and natural resource management (Elbroch et al. 2011; Bear 2017; Wiggins & Crowston 2011; Bonney, Ballard, et al. 2009). Serving multiple roles, CS has evidently provided effective monitoring tools while also promoting public learning, participation and activism (Wiggins & Crowston 2011; Cooper & Lewenstein 2016; McKinley et al. 2017; Bonney, Ballard, et al. 2009). Furthermore, it has been claimed that CS can legitimize science and connect science to society by getting scientists out of the ivory tower (Theobald et al. 2015).

The growth of CS has been attributed to a variety of reasons, including 1) rapid development of information technologies, 2) the increasing need for legitimizing science and science funding and 3) the increased scientific focus on data-intensive science (Silvertown 2009). Szkuta and Osimo (2016), uses the term Science 2.0 to describe the developing scientific landscape of the 21st Century, thus situating the macrotrend CS within a larger paradigmatic shift (Szkuta & Osimo 2016). Science

2.0 consists of three closely related macrotrends, one being CS (the others are open access to scientific output and data-intensive science) (Szkuta & Osimo 2016).

1.1 What is citizen science? Concepts and definitions

Although an increasing number of CS projects are developed across multiple sciences and contexts, important discrepancies exist regarding the meaning of the concept "citizen science" (Kullenberg & Kasperowski 2016; Ceccaroni et al. 2017). It is often claimed that CS is just one of many forms of public participation in research (PPSR) (Bucchi & Trench 2014; Bonney, Ballard, et al. 2009). In other cases, PPSR and CS are considered to be the same entity (Haklay 2015; Riesch 2015). As stated by Eitzel et al. (2017): "*Citizen science terms are dynamic and change over time*" (Eitzel et al. 2017). Accordingly, several definitions of the term "citizen science" are applied - often on what may seem to be a project to project basis (Ceccaroni et al. 2017). Differences in terminology imply differences in applicability (Eitzel et al. 2017). Thus, understanding CS terms – including "citizen science" itself – is essential to evaluate the status and potentials of CS. This study does not aim to propose one definite definition on the term CS, nor does it aim to define what a citizen project is *in essentia*. To create a meaningful analysis of the Danish landscape of CS, however, certain criteria must be applied for meaningful operationalization of the terms "citizen science" and "citizen science project".

1.1.1 The Two Strands of Citizen Science

Reflecting the ongoing debate on the nature of CS, two main strands of CS have emerged during the last decades[1]. The two strands are here labelled "capacity building citizen science" and "instrumentalist citizen science" based on the terminology proposed by Ceccaroni et al. (2017), but other terms have been used also (Ceccaroni et al. 2017; Eitzel et al. 2017; Cooper & Lewenstein 2016). These strands reflect key descriptive and normative differences in how CS is viewed, but they cannot necessarily be described as discrete or demarcated theories (Woolley et al. 2016). As noted, little consensus exists on CS terminology and theory. Hence, both strands of CS can be evident within the same study or project, and the features of the two strands might be complementary rather than mu-

[1] The term "strand" is proposed by Eitzel et al. (2017). For essentially the same conceptualization, Cooper and Lewenstein (2016) use the term "meaning" (Eitzel et al. 2017; Cooper & Lewenstein 2016).

tually exclusive (Ceccaroni et al. 2017; Cooper & Lewenstein 2016; Eitzel et al. 2017; Woolley et al. 2016).

One strand, presented by Irwin (1995) amongst others, underlines the societal importance of CS, as development of scientific citizenship can assist the needs of citizens, legitimize science and create scientific citizenship; thus, CS is a bottom-up "*democratic action*" (Irwin 1995; Cooper & Lewenstein 2016; Ceccaroni et al. 2017; Eitzel et al. 2017; Woolley et al. 2016). In the oft-cited 1995 work "Citizen Science: A Study of People, Expertise and Sustainable Development", CS is presented as a democratizing, engaging and legitimizing entity, which should connect science and society and address the concerns of its citizens while higher scientific capacity is created (Irwin 1995; Mowat 2011; Ceccaroni et al. 2017). As this strand stresses how involvement, dialogue, civic education and empowerment can promote scientific citizenship and democratic values, the term "capacity building citizen science" is fitting to describe this approach to CS (Ceccaroni et al. 2017).

The second strand of CS stresses the scientific contributions of members of the public. This strand has especially been influential in the development of CS-based monitoring programs (Ceccaroni et al. 2017; Cooper & Lewenstein 2016; Dickinson et al. 2010; Bonney, Ballard, et al. 2009). In this perspective, CS is mainly a research tool, as inclusion of a wider public in research can greatly improve the opportunities to collect and analyse data (Dickinson et al. 2010; Eitzel et al. 2017; Ceccaroni et al. 2017). In this instrumentalist view, the development of CS is strongly interconnected with the spread of new digital technologies, as the ability of a crowd to perform scientific work depends on technology access (Eitzel et al. 2017; Dickinson et al. 2010). As such, instrumentalist CS can be quite similar to the concept of "crowdsourcing", as crowdsourcing describes the action, where work – albeit not necessarily scientific work – is distributed to a large group of undefined members of the public (Eitzel et al. 2017; Bücheler & Sieg 2011). Typical features of this top-down, instrumentalist approach to CS are strong professional scientific leadership, well-defined scientific questions and strict protocols (Eitzel et al. 2017; Ceccaroni et al. 2017; Bonney & Dickinson 2012; Dickinson et al. 2010). As noted by Kullenberg and Kasperowski (2016), instrumentalist CS is in this sense similar to concepts such as participatory science, community-based monitoring and volunteer monitoring (Kullenberg & Kasperowski 2016).

1.1.2 Current definitions of citizen science

Several definitions of the term "citizen science" exist. Some definitions reflect strict instrumentalist or capacity building CS, while other definitions incorporate features from both strands. To illustrate the differences in perceptions of CS, a few definitions will be examined with respect to the two above-mentioned strands of CS.

In the literature, CS is described by nouns such as “a paradigm”, “a contribution by the public”, “public engagement” “scientific work”, “public involvement”, “scientific activities”, “a tool”, et cetera, highlighting that little ontological consensus exists on the matter (Bonney, Cooper, et al. 2009; Ceccaroni et al. 2017; Wiggins & Crowston 2011; Bücheler & Sieg 2011).

An oft-used definition of citizen science is the Oxford English Dictionary (OED) definition:

> *Citizen science: Scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists* (Oxford English Dictionary 2018).

The OED definition underlines important aspects of CS. First, CS activities must be scientific. This excludes activities with no scientific scope, thereby distinguishing CS from other activities such as pure activist activities, with no pre-defined scientific goals or methods (Kullenberg & Kasperowski 2016)). However, while pre-determined scientific scopes of such projects may not exist, any activity establishes a potential for scientific discoveries, which could make the distinction less evident in reality. Second, the OED definition states that members of the general public must actively work scientifically. An important criticism of this notion is that a general public does not exist: Rather, the public is constituted of individuals organized in plural communities (Eitzel et al. 2017; Ceccaroni et al. 2017). While such communities can work scientifically, participation in CS is not equally available, relevant or fruitful to all communities, which again influences the potentials for science (Ceccaroni et al. 2017). Moreover, the noun “work” suggests that CS participation is always a deliberate action, thus differentiating CS from citizen-based science projects based on e.g. large-scale data mining (ibid.).

Wiggins and Crowston (2011) use an alternative definition of citizen science:

> *Citizen science is a form of research collaboration involving members of the public in scientific research projects to address real-world problems* (Wiggins & Crowston 2011).

As stated by this definition, CS is “a form of research collaboration”. By using this term, Wiggins and Crowston emphasize that citizens can participate in science in several stages of inquiry throughout the scientific process (Wiggins & Crowston 2011). Like the OED definition, the Wiggins and Crowston definition states that the public involvement must indeed be scientific – thus distinguishing CS participation from non-scientific activities. Contrary to the OED definition, the Wiggins and Crowston definition does not include the notion that members of the public could work under guidance from professional scientists. Hence, this definition puts less emphasis on the traditional, instrumentalist top-down approach to CS. Moreover, according to this definition, CS projects must strive to address real-world problems, much alike Irwin's vision of "assisting the needs and concerns of citizens" (Irwin 1995). For this study, the Wiggins and Crowston definition will be applied in the analysis, as this open-ended definition is more likely to capture the full variation of CS initiatives in Denmark than more rigid definitions.

1.2 What is a citizen science project? Citizen Science project typologies

The diversity of CS projects is immense. As this study aims to review the landscape of Danish CS projects, appliance of CS project typologies provides an analytical tool that refines the review of Danish CS initiatives. Several typologies of CS projects have been offered. Functional traits of CS projects are key factors for distinguishing between project types. Overall, the most important functional traits are project aim and the degree of public participation in the scientific process (Ceccaroni et al. 2017).

By systematically reviewing when and how public participation in scientific research (PPSR) takes place, Bonney et al. (2009) distinguishes between contributory projects, collaborative projects and co-created projects (Bonney, Ballard, et al. 2009). The typology offered by Bonney et al (2009) is presented in figure 1.

Contributory projects are closely related to instrumentalist CS, as public participation in such projects is primarily data collection within programmes led and designed by professional scientists. *Collaborative projects* are typically also led by professional scientists, but the variety of public participation is larger and more reflective of the entire scientific process. Thus, the public can be actively involved in project-design, data analysis and dissemination of the findings. *Co-created projects* involves the public in most or all steps of the scientific process, and the design of such projects is coordinated between scientists and members of the public (Bonney, Ballard, et al. 2009).

Step in Scientific Process	Steps included in Contributory Projects	Steps included in Collaborative Projects	Steps included in Co-created Projects
Choose or define question(s) for study			X
Gather information and resources			X
Develop explanations (hypotheses)			X
Design data collection methodologies		(X)	X
Collect samples and/or record data	X	X	X
Analyze samples		X	X
Analyze data	(X)	X	X
Interpret data and draw conclusions		(X)	X
Disseminate conclusions/ translate results into action	(X)	(X)	X
Discuss results and ask new questions			X

X = public included in step; (X) = public sometimes included in step

Figure 1: Public involvement across citizen science project types. From Bonney et al. (2009).

To further describe the variations regarding design, scope and activities of CS projects, Wiggins and Crowston (2011) proposes a typology of CS project types based on a qualitative review of CS projects with respect to functional and organizational traits. The reviewed projects were scored according to 80 indicative facets (e.g. participant demographics, organizational features, educational features, use of technologies et cetera). Drawing inspiration from the findings of Bonney et al. (2009), Wiggins and Crowston suggest that CS projects can thus be categorized within five types of projects: *Action*, *Conservation*, *Investigation*, *Virtual* and *Education* (Wiggins & Crowston 2011).

Action projects are characterized by local grassroot involvement driven by specific, local concerns. The main scope for such projects is addressing local issues by creating the knowledge base for intervention through research. Most *Action* projects run long-term and are organized bottom-up. Consequently, the scientific contributions of such projects to a broader scientific community can be scarce. Generally, *Action* projects are only dependent on technology to a minimal degree. Local restoration or protection projects are examples of *Action* projects (Wiggins & Crowston 2011).

Conservation projects aim to provide a knowledge base for efficient long-term resource management. Like *Action* projects, *Conservation* projects are typically locally founded. Public participation is mostly focussed on data collection. *Conservation* projects does however emphasise educational goals, as environmental education and awareness does serve conservation and management purposes. As data quality is a prime concern of *Conservation* projects, professional leadership or guidance (e.g. from affiliated scientists and institutions) is often incorporated in such projects. Thus, *Conservation* projects often show top-down (researcher-governed) or middle-out (management initiated) organizational traits. Regarding technology use, *Conservation* projects are distributed bimodulary, showing either little dependence on technologies or strong dependence on sophisticated technologies. Examples of *Conservation* projects include large-scale biodiversity monitoring programmes and government-initiated surveillance of invasive species (Wiggins & Crowston 2011).

Investigation projects aim to collect data for scientific purposes. Thus, these projects are organized top-down with a well-defined hierarchy and work-sharing between organizing, (professional) scientific leadership and amateur contributors. *Investigation* projects incorporate a wide variety of technologies. Strict protocols are often applied to sustain high data quality. Educational goals are often developed within such projects (Wiggins & Crowston 2011).

Virtual projects are entirely dependent on information and communication technologies, as the empirical base of such projects is non-physical. Participation is organized in digital communities. Organized top-down, *Virtual* projects strive to achieve high data quality and quantity through strict protocols and mass-replication. Thus, *Virtual* projects are often closely related to crowdsourcing. Participant motivation and learning is sustained through means such as gamification and performance feedback (Wiggins & Crowston 2011).

Education projects have education and outreach as primary goals. Such projects explicitly target informal or formal learning opportunities, which can be supported by production and distribution of learning materials. While facilitation of learning is the primary objective of *Education* projects, *Education* projects can also serve as a source of data, albeit a relatively expensive one compared to other CS project types within the typology. Moreover, intensive data collection in *Education* projects can negatively impact the degree of participation – and consequently outreach and learning (Wiggins & Crowston 2011).

It is important to note that categorizing Danish CS projects into one of the five project types may not be self-evident, as some projects may share characteristics of several types. For instance, *Education* projects and *Investigation* projects may both promote educational goals. Also, the features of *Conservation* projects and *Action* projects are strongly interconnected; local action may be mediated by large-scale monitoring activities and vice versa (Wiggins & Crowston 2011). Regardless, applying project types from the two above-mentioned typologies to Danish CS projects can provide valuable insights into the important characteristics of the Danish CS projects – and thus their potentials for science, learning, civic action and large-scale societal impacts.

2. Methodology

2.1 The scientific question and units of interest

The principal aim of this study is to review the landscape of CS projects in Denmark to evaluate the status and potentials of Danish CS. Reviewing existing CS projects is key to determine the status and future potentials of Danish CS initiatives – and thus the potentials for CS as a whole. Accordingly, the running CS projects are units of interest for this study. The landscape of CS projects was examined qualitatively.

Central, reoccurring themes of interest and debate were identified in the scientific literature. The key themes identified were 1) the organizational structure of CS projects, 2) participation patterns, 3) data-related issues and 4) the scientific and societal impact of CS. Understanding these themes is essential to assess the current Danish landscape of CS projects and future scientific, educational and civic potentials of CS initiatives. Therefore, scientifically debated themes themselves were determined to be analytical units of interest. Hence, they were investigated using qualitative and quantitative methods.

In this study, data was collected by three different methods and in three different, yet overlapping, phases. The applied mixed methods were chosen to maximize the potential of a credible scientific review of the current landscape of CS in Denmark, hence creating the foundation of a qualified discussion of current and future potentials of Danish CS initiatives. The synergetic use of qualitative and quantitative methods should increase the analytical level of detail as well as the possibilities of meaningful inference (Bøgh Andersen et al. 2012). It must however be stated that the main analytical focal point is on the development side of CS projects, as both the qualitative and quantitative analysis were mostly focussed on CS developers rather than CS volunteer participants. Future studies should investigate the participant side of Danish CS projects more closely. Below is a short description of the applied methods. An overview of the iterative use of methods can be seen in Figure 2.

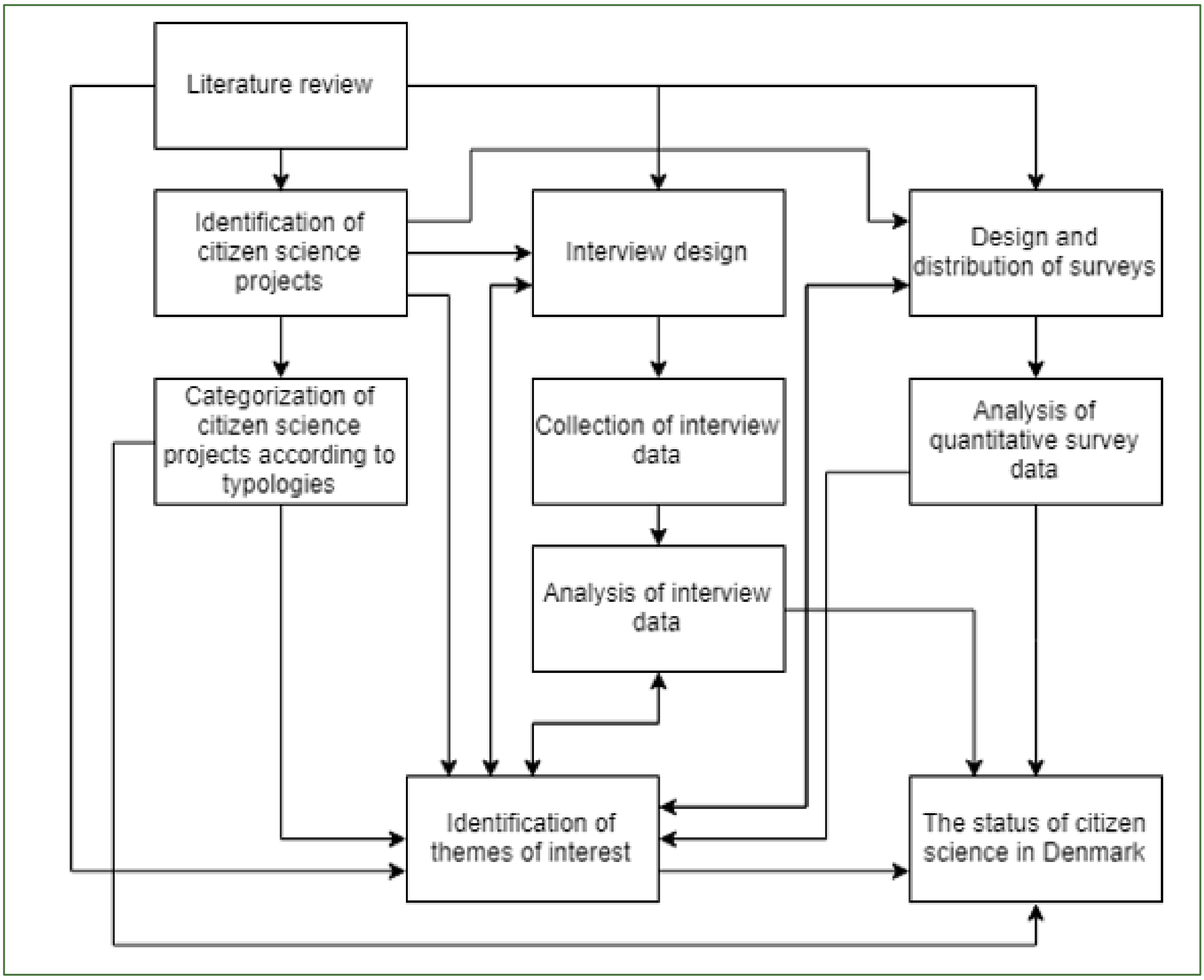

Figure 2: Overview of the iterative use of methods. The figure is created via Draw.io

Method 1: First, CS projects were identified and categorized according to the presented typologies. This was done by a qualitative review of all available information on CS initiatives, which will be addressed further in chapter 2.2.

Method 2: Qualitative data was gathered through interviews with key persons involved in CS projects. Those key persons were identified by method 1. Details on the interview process can be found in 2.3. Thematic analyses were conducted on the interview data to reveal how perceptions of themes among CS project developers might shape the Danish CS landscape (Braun & Clarke 2006). Serving a multi-purpose role, the interviews also revealed themes of interest that were examined quantitatively.

Method 3: Drawing inspiration from the qualitative analysis, quantitative data was gathered through a survey concerning attitudes and experiences with CS projects. The survey was distributed to key persons involved in CS initiatives identified by the initial review of CS projects. To increase the potential for inference, the survey was also distributed to a wider public. Further details regarding survey design and distribution will be addressed in 2.4. Statistical analyses were conducted on the survey-data to explore (connected) patterns of CS involvement and CS-related attitudes and preferences. Understanding such patterns is important to understand the Danish CS project development processes and hence the status and potentials of CS in Denmark.

2.2 Reviewing the landscape: Project identification and categorization

2.2.1 Identification of citizen science projects

As noted, disagreements regarding definitions of CS and CS projects exist. Therefore, stringent operationalization of the concept "citizen science project" is necessary to create a meaningful base of knowledge. Drawing inspiration from the above-mentioned conceptualisations, especially the definition proposed by Wiggins and Crowston (2011), several criteria were applied to determine which activities could be identified as being CS projects:

1. The activities of the initiative must be scientific, and research must be conducted within the project regime. For any given project, the methods, aims and overall process must be developed in congruence with well-established scientific practises, norms and values (Sanz et al. 2014).
2. Members of the public must be involved in the scientific process, and not only as a non-consensual source of data (Eitzel et al. 2017).
3. The initiative must be recognized or at least recognizable. One could argue that CS activities can be carried out by any single individual. To support scientific and civic impact, however, at least some degree of (possible) recognition of the activities is necessary (Kimura & Kinchy 2016).

One aspect also of interest is the degree of organization of any given project. Organized activities are strong indicators of well-developed scientific practises and intent of recognition (Couvet et al. 2008). CS projects may be reflective of the facilitating institutions behind them; many CS activities are organized by science-affiliated institutions such as museums, universities and NGOs. Consequently, projects facilitated by such institutions can be expected to be organized by the same guiding principles that govern other activities within the institutions, which may increase scientific legitimacy and effective governance (Couvet et al. 2008).

Several sampling procedures were used to identify potential CS projects. Potential CS projects were screened ad hoc according to three above-mentioned criteria. Potential CS projects that fit all the criteria were recognized as being CS projects. For this study, a total of 87 different initiatives were identified as being potential CS projects. Of those, 73 fitted the demarcating criteria and of those, 55 were still running within the study period.

First, inspired by other studies, simple Google searches were conducted for terms such as “citizen science Danmark”, “citizen science-projekt", “atlasprojekt”, “frivillig citizen science” et cetera (Vallabh et al. 2016). Many CS projects are promoted through homepages, and key information about the characteristics of a given project can be gathered by examining the affiliated homepages. For instance, descriptions of project design, - methodology, - organization, - funding and - aim were often publicly available. Ad hoc personal contact to project affiliated key persons clarified questions that could not be answered by publicly available information. Valuable information was gathered by examining traditional/mainstream media, as CS has recently become a relatively oft-occurring topic in at least some media. Niche media such as Videnskab.dk and Sciencereport.dk were important sources of information too, as CS-related stories features in both media on a regular basis. A portal of Danish CS projects (citizenscience.dk) was developed while this study took place. The list of identified projects was shared with the developers.

Secondly, scientific literature based on Danish CS projects or monitoring programs was examined to identify potential CS projects and persons affiliated with such projects. Relatively few organizations facilitated the majority of the identified CS projects. Therefore, identification of one project of interest would often lead to other projects of interest, as they were often facilitated by the same organizations or persons.

Thirdly, snowballing sampling techniques were applied (Atkinson & Flint 2011). Primary identification of project-affiliated persons allowed for secondary identification of other persons – and thus projects of interest – within their networks (Atkinson & Flint 2011).

2.2.1.1 Identification: Methodological issues

Some projects were highly promoted and explicitly associated to CS characteristics and terminology. Mostly, these projects originated from science institutions or NGOs. Other projects were cryptic, as they were less noticeable and/or more loosely connected to CS regarding terminology, design, aim and characteristics. Many cryptic initiatives, e.g. “Projekt Vildtvenlig Høst” were not considered to be CS projects as they included no evident scientific content, processes or aim, but were rather pure activist initiatives (Danmarks Naturfredningsforening 2016b; Hvidtfeldt et al. 2016). Other screened initiatives such as “Bliv Naturligvis” were found to be communication projects rather than CS projects, as no research activities were conducted within the project regime (Danmarks Jægerforbund & Danmarks Sportsfiskerforbund 2018). Exclusion of such initiatives was only done after careful consideration, as some communication initiatives can share characteristics with *Education* projects in the Wiggins and Crowston (2011) typology (Wiggins & Crowston 2011).

The existence of umbrella organizations and projects poses a methodological challenge. For instance, the CS driven umbrella initiative "Naturbasen" gathers biodiversity monitoring data through the website "Fugle og Natur" and the App "Naturbasen". While enabling longitudinal monitoring, the "Naturbasen" initiative also facilitates multiple taxon-specific atlas projects (Naturbasen ApS 2018g). Should these initiatives with the same origin, sharing key personnel, infrastructure, methodology and objectives, be treated as one or multiple CS projects? In this study, an ad hoc evaluation was conducted on the qualitative difference between such entities. If the differences between either 1) organizational traits, 2) project aims, 3) methodology or 4) ways of public involvement were substantial, the projects would be treated as separate analytical units, which they were in this particular case (Naturbasen ApS 2018g).

An ongoing question is when projects can be considered to be running. Projects may have a scientific impact and promote learning and civic action even if the day-to-day activities are halted. This proved to be a special concern for *Action*, *Conservation* and *Education* projects (Wiggins & Crowston 2011). "Projekt Odder" is an example of such a case: In 2015, the Danish Society for Nature Conservation (Danmarks Naturfredningsforening) released three otters in West-Zealand. While conservation and monitoring activities has taken place, current and future activities within the project regime are seemingly low-intensity and partly uncoordinated (Håkansson 2017; Baagøe 2017; Danmarks Naturfredningsforening 2018b). Since scientific or civic influence and impact of projects cannot always be determined, a project was determined to be running if participation was possible.

The relaunch of projects at different times posed another methodological issue. For instance, the WWF-led CS project "Opdag Havet 2.0" is in some ways a continuation of "Opdag Havet 1.0" measured by organizational traits, such as project leadership, scientific scope and funding. In this case, "Opdag Havet 1.0" was however deemed a contributory *Investigation* project (which is ended, as public participation is no longer possible), while "Opdag Havet 2.0" was categorized a co-created *Education* project (Tøttrup 2015; WWF Denmark 2018). On the other hand, analogous initiatives were treated as one project if no substantial differences in organizational traits, project aim, methodology or ways of public involvement were observed despite relaunch.

2.2.2 Categorization of projects according to typologies

The identified projects were categorized according to the CS project typologies offered by Bonney et al. (2009) and Wiggins and Crowston (2011). The categorization was based on mainly four parameters: 1) Organizational traits, 2) scientific and civic project aims and 3) project methodology and 4) patterns of public participation. Organizational traits, project methodologies and scientific and civic aims of the identified projects were examined through formal project descriptions, secondary sources (such as promotion materials and interviews in other media) and in some cases via personal contact to key personnel. The patterns of public participation in the identified projects were examined through a review of the project-specific formalized participation processes, e.g. as presented in project descriptions, project status reports and project promotion materials. When possible, participant experiences (e.g. in the form of formal evaluations and experience sharing in relevant fora) were also examined to evaluate public participation patterns.

2.2.2.1 Categorization of projects: Methodological issues

As noted by Wiggins and Crowston (2011), real-life projects may show traits of several theoretical project types (Wiggins & Crowston 2011). This was also the case in this study. Particularly, distinguishing between *Conservation* projects and *Investigation* projects was difficult, as several projects which arguably fell within the *Investigation* category would often be legitimized by conservational arguments. One should however note that *Investigation* projects can serve conservational goals (Wiggins & Crowston 2011). Thus, the categorization process is essentially qualified but subjective. Ultimately, a project was designated the type to which it shared the most characteristics.

2.3 Using interviews to understand citizen science

The use of interviews provide a possibility to understand and explore the reality of the interviewed (Bøgh Andersen et al. 2012). Thus, interviews of relevant persons can provide effective means to increase the knowledge about central issues regarding CS (Bøgh Andersen et al. 2012).

According to Kvale and Brinckmann (2008), the scientific interview process consists of 7 steps: 1) Thematizing the interview, 2) design, 3) conducting the interview, 4) transcription, 5) analysis, 6) verification and 7) reporting (Kvale & Brinckmann 2008). The use of interviews in this study is based on these steps. The interview process will be examined in the following.

2.3.1 Thematizing and designing interviews

The review of scientific literature and the qualitative review of Danish CS projects revealed that several themes reoccurred. Amongst those themes were aims, participation, data-quality, impact, organizational traits and funding. Gathering and analysing interview data from interviewees professionally involved in CS projects present an opportunity to further understand these themes and the practical constraints of CS projects. Therefore, four interviews of persons professionally involved in CS projects were conducted to create an in-depth understanding of central project-related themes and issues. Given resource constraints, the interviewees were purposively selected from the earlier identified and categorized projects to reflect maximum degrees of variation with respect to job responsibilities, affiliated project types and organizational traits of their affiliations (Morse 2011; Bøgh Andersen et al. 2012). Table 1 shows the selected interviewees including a brief description of the associated projects. The projects are categorized using the typologies proposed by Bonney et al. (2009) and Wiggins and Seabrook (2011) (Bonney, Ballard, et al. 2009; Wiggins & Crowston 2011).

Interviewee	**Job title and affiliation**	**Affiliated projects and responsibilities**
IP 1: Julie Koch Sheard	PhD student, The Natural History Museum of Denmark.	Responsible for the scientific content of the contributory *Investigation* project “Myrejagten”.
IP 2: Marie Lillemark	Academic staff member, The Natural History Museum of Denmark.	Responsible for the educational content of the collaborative *Education* project “Real Science – DNA og Liv”.
IP 3: Josefine Møller	Biologist, Danish Environmental Protection Agency.	Co-responsible for invasive species monitoring through the contributory *Conservation* project “Indberetningsportalen”.
IP 4: Thomas Vikstrøm	Organizational project manager, BirdLife Denmark	Responsible for organization of several projects, including the long-running *contributory* Conservation project “Punkttællingsprogrammet”.

Table 1: Interviewees and affiliations

An interview protocol was created to explore the attitudes towards these issues, hereby translating the scientific questions into interview questions. The interview protocol can be located in appendix 1. The interview questions were offered to the interviewees beforehand to promote a comfortable interview situation (Kvale & Brinckmann 2008; Bøgh Andersen et al. 2012). The interviews were designed to be semi-structured (Bøgh Andersen et al. 2012). The duration of an interview was scheduled to be around one hour.

2.3.2 Collection of interview data

The interviews were held in the late spring of 2018 after pilot-testing and information gathering. The interviews were planned via personal contact. To increase the preparedness of the interviewer, all relevant and available information of the involved CS projects were gathered and investigated before the interview was held. Interviewing took place at the workplaces of the interviewees to further promote a safe, comfortable interview situation (Kvale & Brinckmann 2008; Bøgh Andersen et al. 2012). Two recording devices were used to secure data in case of technical problems. The interviews were held after a short briefing that among other things outlined the scope of this study.

Generally, the semi-structured interviews followed the interview protocol, but when topics of interest were covered during the conversation, a few questions were left out to spare precious time and focus on other interesting CS-related aspects of the interviewee's lifeworld (such aspects were often revealed during the conversation). Supplementing questions were asked to address such topics that arose from the conversation. A short ranking-exercise was conducted at the end of the interviews. In this exercise, the interviewee was asked to rank different aims of CS projects based on importance.

According to Kvale and Brinckmann (2008), an interviewer should live up to certain values (Kvale & Brinckmann 2008). Consequently, throughout the interview process, the interviewer intended to maximize empathy, willingness to listen, openness, politeness and preparedness while leading the interview in a productive, critical and structured manner (Kvale & Brinckmann 2008). Notes were taken during the interviews to increase the validity and potential scientific gains from the interviews (Bøgh Andersen et al. 2012; Kvale & Brinckmann 2008). In the end of the interview, the interviewees were asked if they felt that important aspects or questions were missing. This was done to minimize the risk of leaving out central issues from the analysis and discussion of the state of CS (Kvale & Brinckmann 2008). As a sign of gratitude, a small present was given to the interviewee after each interview was finished.

2.3.3 Transcription of interviews

The recorded interviews were listened through several times. Notes of the interview content were taken ad hoc to identify and explore attitudes, issues and general themes of interest for analysis.

As noted by Kvale and Brinckmann (2008), the transcription process is itself an analytical process. Consequently, interviews were transcribed by the author to increase the reliability and validity of the study (Kvale & Brinckmann 2008).

Partial transcription was conducted. This practise holds an element of risk, as important content of interest can be left out of the analysis. However, the level of transcription must first and foremost complement the level of analysis, and for some studies, complete transcription is not necessary (McLellan et al. 2003; Bøgh Andersen et al. 2012). This study focuses on a broad review of the general landscape of CS in Denmark. Thus, identifying important general themes and issues concerning the status and potential of CS was deemed more important than focussing on particularities (McLellan et al. 2003). To test the validity of this method, one interview was fully transcribed and compared to the other partially transcribed interviews. No notable difference for the potential analytical impact was found. Thus, the practise was considered acceptable. The following will provide a more in-depth description of how transcribed quotations was used in this study.

2.3.4 Interview analyses

Thematic analysis was done based on the procedures proposed by Braun and Clarke (2006). According to Braun and Clarke (2006), *"[a] theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set*" (Braun & Clarke 2006). Themes can be identified through either 1) inductive bottom-up data-driven ways or 2) deductive top-down theoretically founded ways. Theme identification is an iterative process (Braun & Clarke 2006).

For the thematic analysis conducted in this study, top-down themes originated from the scientific literature and the initial review of Danish CS initiatives. The interview protocol was developed according to these themes. Unsurprisingly, these themes were rediscovered in the interview data, which may be an indicator of successful translation of scientific questions to interview questions (Kvale & Brinckmann 2008; Bøgh Andersen et al. 2012). Bottom-up themes, albeit not many, arose from the analysis of interview data. The identified bottom-up themes were generally sub-topic complementations to the top-down themes, as they provided more in-depth understanding of the top-down themes of interest. For instance, it was revealed how *technology* and *participation* (two top-down themes of interest) interacted. One sub-topic of interest that was revealed bottom-up was "The international context of CS".

For each interview, interviewee attitudes towards each theme were assembled thematically. For instance, all relevant opinions regarding the theme *participation* were written down. Quotes were used when they could directly be translated into attitudes. In other instances, some interpretation was necessary to decode a multitude of connected thoughts and quotes into reportable attitudes towards CS (Braun & Clarke 2006).

2.3.5 Verification: Validity and reliability

Validity and reliability can be difficult to measure and sustain in qualitative research (Kvale & Brinckmann 2008; Bøgh Andersen et al. 2012). Therefore, they were primary concerns during all interview phases as they should be (Kvale & Brinckmann 2008). During the formulation of interview questions, the interviewer must always keep the scientific hypotheses in mind (Kvale & Brinckmann 2008; Bøgh Andersen et al. 2012). Therefore, the interview protocol was thematized according to the earlier identified themes. As noted, the rediscovery of these themes in the analysis could indicate that the translation was successful, suggesting that high validity may have been achieved for this matter. As noted, optimization of reliability and validity were also carefully sought-after during the transcription phase.

To increase reliability and ensure a high ethical standard, the interviewees were presented the opportunity to read and confirm the interview transcript (Kvale & Brinckmann 2008). One interviewee made such a request and received a full transcript. No problematic comments were returned.

2.3.6 Reporting the findings of the interviews

The scientific findings of the interviews are presented in chapter 3.2. As noted, the reporting will be theme-based. As the interviews were held in Danish, all quotes are translated as directly as possible.

2.4 Surveying the landscape: A quantitative review of CS-related issues

The use of surveys provides an opportunity to gather large quantities of data and thus create the foundation for statistical inference (Bøgh Andersen et al. 2012). In this study, statistical analyses were mainly conducted to reveal citizen-science related attitude and participation patterns, as uncovering of such patterns can give important insights into the status and potentials of CS.

2.4.1 Design and distribution of surveys

An online survey was designed using SurveyXact. The questionnaire can be located in Appendix 2. The questionnaire could be answered anonymously, and respondents were ensured that sensitive personal information would not be shared with others. The questionnaire was designed according to the themes identified in the scientific literature, in the initial review of projects, and in the analysis of interview data. To maximize validity and reliability, all questions were designed to be as simple and uninterpretable as possible (Bøgh Andersen et al. 2012).

The types of questions asked in the survey can be divided into four subsets:

- Background questions regarding the age, education level and employment status of a respondent.
- Involvement questions, e.g. how a respondent has been involved in CS projects, both professionally and as a voluntary participant.
- Attitude questions, e.g. how a respondent perceives CS-related topics.
- Preference questions, e.g. how a respondent would hierarchically rank certain CS-related items.

Background questions (regarding age, education level and employment status) were designed to gain insights into the demography of the respondents. Controlling for such background variables is essential, as they can have significant statistical impact on the analysis (Bøgh Andersen et al. 2012; Agresti & Finlay 2009). Involvement questions were asked to reveal how group-affiliations might shape the attitudes and preferences of respondents

The order of attitude questions was randomized to reduce the risk of potential biases. A 6-item Likert-scale was used in the question batteries as it increases the validity of the investigation. Also, Likert-scaling creates the opportunity to use parametric statistical tests on ordinal-scaled data assuming the distance between categories is equidistant and symmetrical. As an "undecided"-category was used, this is a reasonable assumption (Bøgh Andersen et al. 2012; Agresti & Finlay 2009).

A ranking experiment was conducted in the end of the survey to reveal the preferences of respondents. Unlike attitude questions, preference questions can address the comparative placement of items (Phillips et al. 2002). Here, respondents were asked to rank criterions of success for CS projects on a scale from 1-7 and CS project-related challenges on a scale from 1-10 based on importance. Hence, a low value reflects that a respondent ranked the criterion of success or challenge to be important. As the ranking-answers would be autocorrelated by definition (a high ranking of one item would reduce the rank of another item by default), it is not meaningful to analyse correlations between the ranking items. It is however meaningful to compare the mean rank of items between groups under the assumption that the distribution of items is symmetrical (Mannemar Sønderskov 2011).

Surveys were distributed to two groups of potential respondents in the summer of 2018. Group A consisted of almost all key persons (professionally) involved in CS project development in Denmark. These potential respondents were identified during the aforementioned identification phase. Respondents within this group were contacted by an email containing a personal link to the survey. The personal link ensured that the survey could not be answered by others, thus optimizing the validity of the study. A direct link was also distributed to project-affiliated email-addresses. One should note that the potential sample size is constrained by the simple fact that only few persons are professionally involved in CS projects in Denmark.

Group B consisted of qualified lay-people, mostly from the Facebook groups "Biodiversitet.dk" and "Biologi" and the LinkedIn group "Citizen Science Netværk". A short description of the purpose of the survey was attached a non-personal link to the survey. These closed, interest-based communities are not likely to be reflective of the general population, which may cause a bias that diminishes the possibilities for meaningful statistical inference (Bøgh Andersen et al. 2012). However, the selective distribution to these groups was intentional, as persons within these communities can be expected to have a larger knowledge – and possibly more refined attitudes – regarding CS. As the aim of this study is to review the landscape of Danish CS, gathering high-quality observations (albeit at a cost of possible inference) was considered more important than acquiring more data from respondents unfamiliar with CS; the latter strategy could be a source of serious response bias (Bøgh Andersen et al. 2012).

2.4.2 Statistical analyses of survey data

The collected survey data was analysed using Microsoft Excel and the statistical software Stata. In correspondence with good practice, statistical analyses were performed after data-clearing (e.g. by recoding of variables, designation of missing-values and variable labelling) (Mannemar Sønderskov 2011; Bøgh Andersen et al. 2012).

First, descriptive analyses of demographics and CS involvement were conducted within the sample. Second, between-group comparisons were conducted to examine if attitudes or preferences differed between groups within the sample. χ^2 testing was used for testing of statistical independence of categorical variables. Two-sample t-test was used when a group variable had two categories and the independent variable was considered metrical. The two-sample t-tests were conducted assuming unequal variance. Bonferroni-corrections were used to adjust standard errors to reduce the risk of Type I errors (Mannemar Sønderskov 2011; Agresti & Finlay 2009).

It must be stated that while statistical inference to the general population might not be possible given the selective sampling procedures, statistically valid results can be achieved in between group-comparisons.

3. Results

3.1 Results: Identification and categorization of projects

A total of 55 currently active CS projects were identified and categorized. The trends regarding types of projects are summarized in table 2. The entire list of categorized projects can be found in Appendix 3. In the following, the projects will be presented by their type according to Wiggins and Crowston (2011). All projects are labelled by their original title to avoid confusion.

Type according to Bonney et al. (2009) / Type according to Wiggins and Crowston (2011)	Contributory	Collaborative	Co-created
Action	None	None	2
Conservation	15	2	None
Investigation	21	1	1
Virtual	5	3	None
Education	None	4	1

Table 2: The distribution of identified CS projects according to the typologies offered by Bonney et al. (2009) and Wiggins & Crowston (2011). The entire list of projects can be found in Appendix 3.

Evidently, the vast majority of Danish CS projects are ecology-focused *Conservation* and *Investigation* projects. Many projects were somewhat redundant. For instance, 9 projects involved monitoring of insects, albeit at different taxonomic levels and with different methodologies.

17 projects were considered to be *Conservation* projects, while 23 were categorized as *Investigation* projects. As noted, these two project types are often related, and the practical distinction between the two types is mostly defined by the use and impact of project data, which may shift over time.

72 percent of the *Conservation* and *Investigation* projects fell within the *contributory* category, as public participation was almost exclusively limited to data collection. Notably, most *Conservation* and *Investigation* projects were wide-scale studies with only few local initiatives being identified. Partnerships were often integral to the large-scale projects. Project scopes varied between either single-taxon oriented initiatives and large-scale monitoring projects.

Interestingly, a huge proportion of the single-taxon oriented initiatives within the *Conservation* and *Investigation* categories were facilitated by Naturbasen Aps, which could indicate how influential digital infrastructure is on project design and aims. Few other single-taxon oriented initiatives were organized by interest communities. These projects were generally characterized by primitive digital infrastructure. Notably, the majority of the *Conservation* and *Investigation* projects were at least partly organized by universities and natural history museums. For the entire sample, natural history museums and/or universities were involved in more than half of all identified projects, amongst those many highly visible projects such as “Naturtjek”, “Fangstjournalen” and “Fiskeatlas”.

Three NGOs (BirdLife Denmark, the Danish Hunter’s Association and the Danish Society for Nature Conservation) were responsible for more than half of the categorized *Conservation* projects. This could indicate that CS projects provide considerable scientific evidence – and possibly political leverage – for these influential NGOs.

Only one government led project (Indberetningsportal – Invasive Arter) was identified. The governmental influence on the landscape of CS is likely to be higher, though, as both “Vingeundersøgelsen” and “Vildtudbyttestatistikken” represent partnerships between Aarhus University (DCE) and the Ministry of Environment and Food of Denmark. Also, the BirdLife Denmark-led project “Punkttællingsprogrammet” is entirely funded by the Ministry of Environment and Food of Denmark (Dansk Ornitologisk Forening 2018c; Thomas Vikstrøm, personal communication).

2 *Action* initiatives were found. They were both organized by University of Southern Denmark and Odense University Hospital. Focussing on health-related issues, these projects differed substantially from the general landscape of Danish CS projects. Public involvement was important in all project phases. In the *co-created* project “Et sundere Fyn”, involvement of the local broadcast station TV2 Fyn enabled the public to shape project content. Ultimately, the public directly allocated funding to their desired project (Syddansk Universitet 2018c; TV2 Fyn 2018).

8 projects were defined as *Virtual* projects, however only 3 institutions organized these projects, with Science At Home at Aarhus University being the most visible – and arguably the most innovative. Gamification was an essential part of Science At Home projects, as these *contributory* projects

use participant data to model cognitive science, physics and quantum mechanics. The activities coordinated by the Danish Royal Archives resembled crowdsourcing to a large extent, as public involvement mostly consisted of transcription of non-digital data.

5 projects fell within the *Education* category. These projects had education as their main scope, but huge variations in public participation were observed, regarding e.g. target groups, scientific purposes and the use of formal and informal education materials. Various target groups were identified, and notably, all projects included data-gathering for scientists to some extent. Four *Education* projects were considered *collaborative* projects, as participation in all projects included data analysis, data interpretation and dissemination. "Opdag Havet 2.0" was categorized as a co-created project since participants were partly responsible for development of project content and methodology (WWF Denmark 2018).

To summarize, while the Danish CS landscape is diverse with respect to project aims, project designs and organization of projects, the majority of Danish CS initiatives are ecology-focussed *Conservation* and *Investigation* projects with limited ways of public participation. Hence, collection of data appears to be the prime target of most projects across organizational contexts. One should however recognize that many, often recently launched, initiatives integrate public participation throughout the scientific process.

3.2 Results: Thematic analysis of interview data

The following themes of interest were either discovered during the literature review, during the identification and categorization of projects or during the thematic analysis of the interview data. The thematic overview is presented in table 3. Most main themes and sub-topics were integrated in the designed interview protocol, but the sub-topic "The international context of CS" was revealed as a result of the thematic analysis. In the following, notable results from the qualitative thematic analysis will be presented according to these themes. It is however of utmost importance to notice that the main themes (and sub-topics, for that matter) were revealed to be highly interconnected.

Main theme	Sub-topics
Organization and practical constraints	- Facilitating institutions and the strategic use of CS - Funding - Technology - The international context of CS
Participation	- Ways of participation - Promotion and recruitment - Participant motivation
Data	- Data quality and quantity - Data quality control
Citizen science impact	- Scientific impact of CS - Societal impact, including civic education and action

Table 3: The identified themes of interest after top-down and bottom-up thematic analysis (Braun & Clarke 2006)

3.2.1 Organization and practical constraints

3.2.1.1 Facilitating institutions and the strategic use of citizen science

All interviewees expressed the important role of facilitating institutions (in a wide sense) for CS development. All interviewees concurred that strategic decisions made by their employer had a positive influence on CS project development. All interviewees recognized the media to play a vital role for CS development and spread. IP 1 and IP 3 claimed that increased organization and cooperation between CS project stakeholders would be beneficial, and IP 3 further elaborated that future launching of the EPA initiated partnership-project “Artsportalen” would support closer organization.

IP 1 and IP 2 underlined that their employer, the Natural History Museum of Denmark (NHMoD), explicitly linked the use of CS to fulfilment of the visions of the organization. According to these interviewees, CS projects represent a possibility to connect scientific research with science communication and promotion of the organization. As stated by IP 1 and IP 2, the NHMoD holds valuable expertise regarding project development. IP 1 and IP 2 considered scientific expertise to be very important for CS project design, and consequently, the NHMoD was deemed a natural focal point for CS development by the two interviewees. IP 2 underlined the importance of innovative spirit, risk-willingness and professional synergies created in the cultural meeting between different branches of personnel groups within the organization. IP 1 emphasized the instrumental role of professional scientists in CS project development:

"I think of the scientists as organizers – and possibly also as analysers and summarizers. They are the ones who help by creating the project in a way that makes it scientifically useable, so everything is standardized, and everyone does the same thing."

To further elaborate how scientific considerations shaped CS project design, IP 1 stated that the scientific question defines the use of CS, as CS is a powerful data-collection and attitude-shaping tool.

International obligations and strategic leadership decisions were the main drivers of CS development within the Danish Environmental Protection Agency (EPA) according to IP 3. EU-regulations regarding monitoring of invasive species, combined with a strategic desire to increase public awareness towards the EPA and involvement in policy-making, laid the foundation for the CS project "Indberetningsportalen – Invasive Arter" as expressed by the interviewee.

IP 4 stated that CS projects were prioritized higher than all other initiatives within the organization (BirdLife Denmark):

"All our other projects are almost completely subordinated to our CS projects. (…) We have only few projects, which are not CS projects – they don't count for nearly as much."

IP 4 also stressed that BirdLife Denmark's idealistic, political use of CS projects requires central coordination. As BirdLife Denmark is organized in local units, organizational infrastructure must be developed and maintained to achieve the CS-related strategic benefits of the organization's idealistically motivated members.

3.2.1.2 Funding

All interviewees considered limited and insecure current and future funding to be the prime concern for CS. All interviewees did however agree that CS could be less exposed to limited funding compared to traditional science, as CS can represent a relatively cost-efficient data-source with societal impact. IP 1 noted that increased funding of CS initiatives had caused more positive attitudes towards CS in parts of the scientific community. A troublesome feature regarding CS funding was identified by IP 2, as foundations tend to allocate funding to *either* scientific initiatives or communication initiatives, thus potentially minimizing funding for CS projects that incorporate both aspects.

3.2.1.3 Technology

All interviewees considered new communication technologies and digitalization to be main drivers of CS development. While technological progress did promote higher participation, participant motivation and effective data-collection according to the interviewees, some negative features of increased digitalisation was also revealed during the interviews. Namely, IP 4 considered technical problems to be “disastrous”, as such issues could demotivate (potential) participants and harm data-collection. IP 3 noted that technical maintenance of “Indberetningsportalen – Invasive Arter” was subcontracted.

3.2.1.4 The international context of CS

Interestingly, all interviews revealed that CS development must always be understood in an international context. IP 1, IP 3 and IP 4 stressed that their affiliated projects (Myrejagten, Indberetningsportalen – Invasive Arter, and Punkttællingsprogrammet, respectively) were all inspired by foreign CS projects. Moreover, IP 3 noted that international obligations facilitated project development. IP 2 and IP 4 emphasized the importance of international recognition, as international recognition led to more positive stakeholder-attitudes towards the CS projects in question. Such stakeholders were either participants (IP 4) or organizing personnel or decision-makers (IP 2).

3.2.2 Participation

3.2.2.1 Ways of participation

All interviews revealed that participants were active in data-gathering[2]. IP 4 noted that participants could take on a pure facilitating role in “Punkttællingsprogrammet”, working e.g. as secretaries or cooks. IP 2 described how participants were actively involved in data analysis, data dissemination and methodological discussions in the *Educational* project “Real Science – DNA og Liv”. Furthermore, IP 2 stressed a desire to involve the public even more “*in formulation of scientific questions and project design*”. IP 1 and IP 4 elaborated that CS participation in some instances may be viewed upon as an entertaining activity rather than a scientific contribution. IP 1 did however notice that if CS participation was merely entertaining, then the degree of interest from participants towards “Myrejagten” would likely be lower than she experienced.

3.2.2.2 Recruitment and promotion

Recruiting participants for CS projects was a prime concern according for all interviewees. Thus, recruitment campaigns were used. It was revealed that all interviewee-affiliated projects incorpo-

[2] This feature was also revealed during the categorization-phase.

rated CS data-driven news for such recruitment purposes. IP 1, IP 3 and IP 4 stated that promotion materials could enlarge recruitment and increase participant motivation, albeit to a varying, context-dependent extent.

All interviewees agreed that recruitment of participants was very dependent on participant's attitudes towards the CS projects and the organizations behind. Positive attitudes were created and maintained via feedback mechanisms.

All interviewees identified recruitment networks as an effective way to enhance participation in CS projects. According to the interviewees, such networks could be either institutional or personal. IP 1, IP 3 and IP 4 noted that the recruitment base for CS projects can be limited, as participation is often driven by personal interests. Also, IP 1 emphasized that project-specific traits may influence recruitment: "*The more complex the way of public participation, the less participants*". IP 1 further elaborated that to maximize participation, the scientist must increasingly become a communicator.

All interviewees recognized promotion of the project-associated organization to be an objective for CS projects. IP 3 stressed that increased visibility of the EPA was a main strategic goal, which CS initiatives could aid. Contrary to that notion, IP 4 stated that having promotion and strengthening of BirdLife Denmark as main goals for "Punkttællingsprogrammet" would be inappropriate; such goals should rather be considered as positive side effects – which were realized – according to the interviewee.

3.2.2.3 Participant motivation

Keeping participants motivated was a prime concern for all interviewees. According to all interviewees, the most important source of motivation was assuring participants that their contributions were actively used – be it for scientific (IP 1, IP 2, IP 4) –, management (IP 3) – or political (IP 4) purposes. As stated by IP 4: "*We always make sure to tell the participants that their results are being used*". IP 4's statement supplements his general notion that participants are often motivated by idealistic concerns. Also, community formation, for instance facilitated through social and scientific arrangements, was considered a driver for CS participant motivation according to IP 4.

IP 1 and IP 2 claimed that assisting scientists was also a major motivational factor for CS participants. These interviewees further claimed that generating authentic scientific data and knowledge was motivational for participants. IP 3 considered problem familiarity – in this case prior negative experiences with invasive species – to be a determining factor for CS participation and participant motivation.

A key source for motivation was feedback mechanisms according to all interviewees. Personal feedback was incorporated in all interviewee-affiliated projects, at least to some extent. IP 4 considered tracing of personal progress via feedback to be a prime objective for CS projects facilitated by BirdLife Denmark. Hence, technical breakdowns could do severe damage to individual motivation according to this interviewee. All interviewees recognized that feedback from participants to project organizers was noticeable and important.

IP 1 and IP 2 stressed the motivational importance of CS participation-associated learning. IP 3 and 4 recognized that CS participation could increase learning, but these interviewees considered learning to be more of a positive side-effect. IP 2 emphasised the importance of experiencing a new learning environment on participant motivation:

> "*I think this is new to many of them: That there is not only put emphasis on what they know, but also on what they can do*."

By her opinion, the innovative, practical "Real Science – DNA og Liv" setting was highly motivative for students, possibly even more so for students who did not usually perform well in traditional learning situations.

3.2.3 Data

3.2.3.1 Data quality and quantity

All interviewees acknowledged the potentials of CS projects to collect large quantities of data across large temporal and spatial scales in a cost-effective way. All interviewees stated that (initial) scepticism against CS data quality could be profound in some communities. However, all interviewees considered the data quality of CS projects to be high in general. Still, all interviewees agreed that participation patterns could cause biases. Hence, all interviewees concurred that minimum thresholds regarding data quality must be reached and sustained through development of strict protocols for data to have an impact.

All interviewees considered random data errors to be relatively unimportant if enough data is recorded. Some discrepancies were noticeable, though. IP 4 expressed that another NGO (Bæredygtigt Landbrug, no English title) had questioned the data quality of BirdLife Denmark's CS project "Punkttællingsprogrammet" to promote its own political interests. IP 3 stated that the use of CS data for management purposes is significantly different from scientific use of CS data. Namely, IP 3 considered each observation to be potentially influential for management decisions. According to IP 3, whereas careful modelling can reduce the risk of sampling biases in science, this is not a viable option when CS data is used in management, especially when management practices are also shaped by international obligations. IP 3 further noted that a key bias in her affiliated project, was that participants reported rare species relatively often compared to common species. Hence, statistical outliers could blur the general landscape, which is worrisome in this case, since CS data was translated into management strategies.

IP 1 stated that data quality is more important than data quantity, as biased data can severely harm the CS based scientific investigation:

> *"You can have as much data as you could possibly want, but if it is not reliable, and you don't trust it, then you can't use it. And then you cannot use it for publications."*

Hence, scientific leadership of CS projects would minimize the risk of potential biases – and increase scientific impact – according to IP 1. The importance of such leadership was deemed increasingly important as data errors cannot always be detected within a CS project sample according to this interviewee.

3.2.3.2 Data quality control

All interviewees agreed that strict protocols are essential to sustain data quality. All interviewees stated that control mechanisms were adopted to validate data in their affiliated CS projects, as scientific filters (such as validation procedures and statistical modelling) could increase data quality and the potential impact of CS data. Validation of CS data was done by scientists (IP 1, IP 2), employees of the EPA (IP 3) or by members of the scientific committee in BirdLife Denmark (IP 4). IP 3 further stated that future formation of automatic validation procedures (such as photo-recognition and validation networks) would increase data validity and thus CS project impact. IP 1 and IP 4 emphasized that scientific leadership was an efficient way to ensure data quality, as scientifically developed protocols would serve as data quality filters.

IP 3 and IP 4 considered participant seniority to be a key parameter of data quality. Hence, both interviewees stressed the importance of personal networks to evaluate participant capability. IP 4 stated that self-evaluation (with respect to participant capability) was prominent amongst participants in BirdLife Denmark facilitated CS projects. Moreover, IP 4 expressed that self-evaluation amongst participants with respect to their capabilities was often too harsh.

3.2.4 Citizen science impact

3.2.4.1 Scientific impact of CS

All interviewees concurred that the potential scientific impacts of CS projects are immense, as CS can provide cost-effective methods to scientifically investigate objects of interest across large temporal and spatial scales. All interviewees agreed that for CS projects to have scientific impact, high data quality must be achieved. Consequently, development of strict protocols, thorough method testing, and data validation was considered essential by all interviewees.

IP 2 stated that scientific impact was not limited to the generation of scientifically useable data. According to this interviewee, CS projects can serve as an explorative way of method testing and "*proof of concept*". Both IP 1 and IP 2 claimed that participation in CS projects could increase the scientific knowledge, interest and citizenship amongst participants, hence possibly forming the next generation of scientists, which would have immeasurable scientific and societal impacts. IP 2 considered the relationship between scientific research and societal impact to be synergetic.

Also, an interesting feature was revealed by IP 1, as she felt that participation in CS-based research was extremely motivating for the scientist. Consequently, motivating CS based research may therefore increase the general scientific output and impact due to higher scientist motivation.

IP 1 stated that CS based research was considered second-tier research within parts of the scientific community, partly because many CS projects are not translated to scientific output. IP 2 and IP 4 also stated that scientific scepticism against CS was a key issue, yet IP 1, IP 2 and IP 4 all claimed that scientific scepticism could be reversed if scientifically acceptable results were created through CS projects.

3.2.4.2 Societal impact of CS

All interviewees concurred that CS can have extraordinary implications for society. However, the interviewees thought differently about which specific societal impacts CS could cause.

IP 4 underlined the idealistic, political role of CS projects and CS project-generated data, as CS can provide unique data and thus political leverage for an NGO like BirdLife Denmark. Hence, IP 4 deemed CS:

> *"a completely necessary means for us to participate in nature policy-making… At least most nature policy-making"*

According to IP 3, CS could promote evidence-based management and legitimize management practises. IP 3 did however notice that an asymmetrical relationship may exist between managers (in this case the Danish EPA) and the general public: While CS data is considered an integral part of the Danish management strategies regarding monitoring of invasive species, the general public may not think of invasive species as a problem. Hence, public participation in CS could be lower than needed to sustain effective management – both in terms of raising public awareness and collection of CS data.

IP 2 emphasized the educational value of CS. Educational aims could be measured within two scopes: 1) Learning of important practical abilities and subject knowledge for students and 2) large-scale development of conscious, scientific citizenship. As noted by IP 2:

> "*We need citizens who are able to take a stand, who dare to ask questions and make choices. And they must be able to be critical and reflective about data and results, and what they read in the newspapers, and what our politicians say… A scientific project like this can aid such advances – and we need more.*"

Adding to this point, IP 1 and IP 2 both stated that CS could facilitate dialogue between science and society, as CS can reveal the machinery of science and get scientists out of the ivory tower. Hence, CS was considered to be a legitimizing entity, which could promote societal and scientific interests alike. IP 1 further elaborated that CS can change population attitudes regarding nature, and thus promote conservational aims through increased environmentalism.

3.3 Results: A quantitative review of CS involvement and CS-related attitude patterns

A total of 206 observations were collected through the survey. Some respondents did not answer all questions or complete the questionnaire, hence making the sample size smaller for some variables. The response percentage was at least 40 for Group A, as surveys were also distributed to project-affiliated email-addresses. The response percentage for Group B cannot be measured as respondents within this group did not receive a personal link.

3.3.1 Sample demographics and CS involvement

The following tables and graphs summarize patterns of involvement in CS across the demographic parameters age and education.

3.3.3.1 Citizen science voluntary participation

Within the sample, 38 percent of the respondents had participated in CS projects at some point. 58 percent had never participated. 4 percent were undecided. The mean age was 40.47 and did not differ significantly between the groups. The results are summarized in table 4.

Voluntary participation in CS projects?	**Frequency**	**Percentage of sample**	**Mean age ± SD**
Has never participated in CS projects as a volunteer	107	57.84	38.81 ± 15.02
Has participated in CS projects as a volunteer	70	37.84	43.21 ± 13.11
Undecided	8	4.32	38.63 ± 11.95
Total, n = 185	185	100.00	40.47 ± 14.30

Table 4: Citizen science voluntary participation within the sample (n = 185)

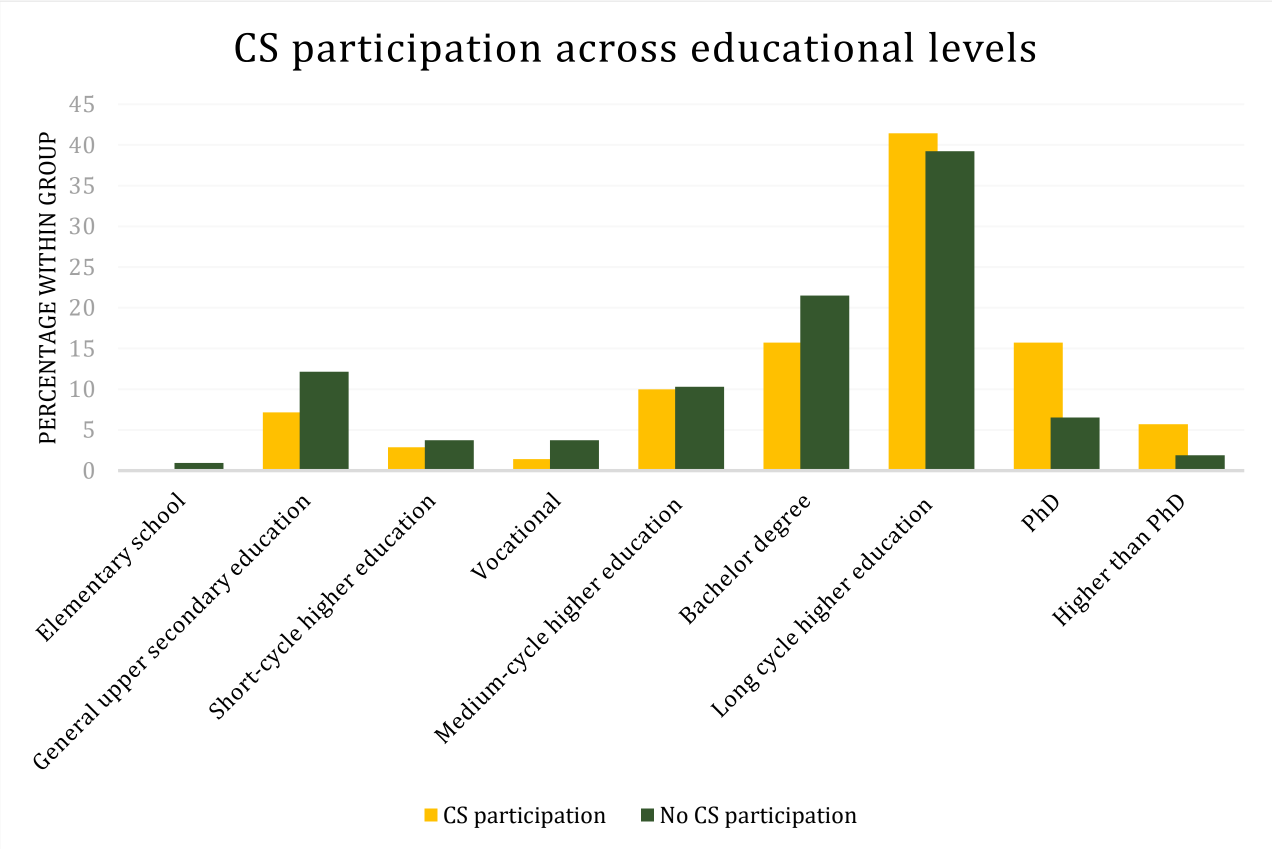

Figure 3: CS voluntary participation across educational status. n = 185. Percentage within group measures the percentage for either "CS participation" or "No CS participation" for each education category.

The relationship between educational level and CS voluntary participation was examined. Figure 3 illustrates the relationship. No respondents were selected “Others” or “Undecided” for this question. Accordingly, these categories are left out.

As indicated by figure 3, the general educational level within the sample was higher than population average (Danmarks Statistik 2018) . Also, the figure indicates that CS participation varies across educational levels, as participants with higher educational level would relatively more often participate in CS as volunteers. It was also revealed that professionals involved in CS projects would be CS project volunteers significantly more often than other respondents. As this sample is not representative of the general population, it cannot be generalized that higher educational level is positively correlated with CS project participation. It is an interesting notion however, and this possible pattern should be examined in future studies.

3.3.3.2 Professional involvement in CS projects

Hereafter, the respondents, who at some point had been involved in CS projects, is referred to as professionals involved in CS (PIICS). The self-reported knowledge about Danish CS projects was significantly higher for PIICS compared to other respondents. No significant differences in self-reported knowledge about Danish CS projects was observed when comparing of active PIICS to earlier-involved PIICS.

Table 5 shows the distribution of respondents according to their level of professional involvement in CS projects.

Professionally involved in CS project development?	**Frequency**	**Percentage of sample**	**Mean age ± SD**
No professional involvement in CS projects	113	62.09	40.60 ± 15.86
Yes, involved now	47	25.82	40.50 ± 10.59
Yes, involved earlier	20	10.99	40.25 ± 11.91
Undecided	2	1.10	37.50 ± 16.26
Total, n = 182	182	100.00	40.51 ± 14.17

Table 5: Professional involvement in CS, age distribution. n = 182

The mean age was 40.51 and did not variate significantly between the groups. 62 percent of the respondents had never been professionally involved in CS projects. 26 percent of the respondents were involved professionally now while 11 percent of sample respondents had been professionally involved in CS projects earlier. Thus, 37 percent of the respondents had been professionally involved in CS projects at some point. This underlines that this selectively distributed sample is not reflective of the general population trend.

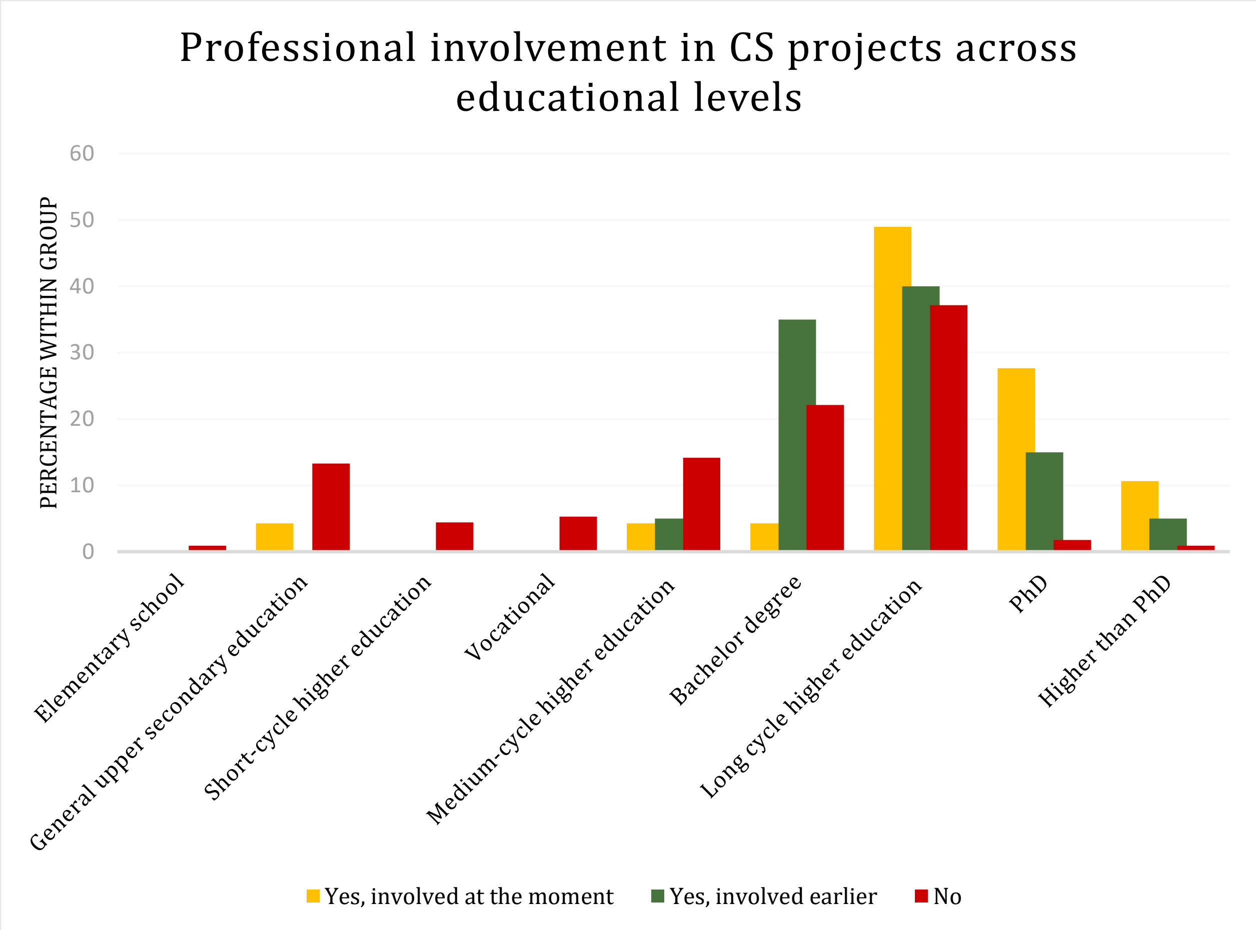

Figure 4: Professional involvement in CS projects across educational status. n = 182. Percentage within group measures the percentage for either "Yes, involved at the moment", "Yes, involved earlier" and "No professional involvement" for each education category.

Figure 4 indicates that PIICS had a higher educational level than respondents with no earlier or current professional involvement in CS projects. As revealed by the within-group percentages, a relatively high proportion of PIICS had at least passed a long-cycle higher education. This can likely be attributed to the fact that majority of the identified CS projects were professionally organized by scientists and academic staff members.

The PIICS were divided into 4 groups reflecting in which type of organization, they had been professionally involved in CS projects. The 4 types of organizations were 1) science institutions, 2) NGOs, 3) public management institutions and 4) private organizations. 47 PIICS were currently or earlier involved in CS projects in science institutions. 26 PIICS were currently or earlier involved in CS projects in NGOs. 9 PIICS had at some point been professionally involved in CS in public management institutions. 5 PIICS were currently or earlier involved in CS projects in private organizations. However, many PIICS were currently or earlier professionally involved in CS projects in several organization types. The organizational distribution of PIICS is reflected in table 6.

PIICS involvement in multiple organizations	**No. of PIICS within category**
Science institutions and NGOs	13
Science institutions and public management institutions	7
Science institutions and private organisations	4
NGO's and public management institutions	4
NGO's and private organizations	5
Public management institutions and private organizations	4
More than two types of organizations	4

Table 6: PIICS involvement across organization types. n = 180

Evidently, many PIICS had been involved in CS projects in multiple organization types. This is an interesting notion, as that may indicate that CS project development could be facilitated by relatively few PIICS, which might spur discussions of path-dependency. This topic will be addressed in chapter 4.

3.3.2 A quantitative review of the perception of citizen science and citizen science projects

Several variables measured CS-related attitudes. The following tables summarizes some key trends within the sample.

As noted earlier, discrepancies exist regarding the meaning and purpose of CS. This was also evident within the sample. Question A measures the perception of CS. The results are shown in table 7.

Half of the respondents considered CS primarily to be a data-gathering scientific instrument. Non-involved and PIICS shared this notion alike as reflected by the roughly equal column percentages. 30 percent of the respondents considered CS to be mainly a deliberating, educational venture. Notably, currently active PIICS were less likely to state that opinion. Within the sample, 12 percent deemed CS principally to be a tool for solving societal issues. This opinion was relatively uncommon among formerly active PIICS, but the difference could be attributed to the relatively small sample size. Only one respondent considered CS to be mainly a communication tool. χ^2 testing did not reveal statistical dependence between PIICS status and CS perception (as measured by Question A) at $\alpha = 0.05$, which may indicate that attitudes towards CS are relatively stable across the selected groups.

Question A: Citizen science is…	Professional involvement in CS projects? Column percentages are shown in parentheses			
	No	Yes, involved now	Yes, involved earlier	Total
a scientific instrument designed to collect data for scientists	37 (48.68)	22 (51.16)	9 (50.00)	68 (49.64)
a deliberating venture aimed to educate and engage the public	26 (34.21)	10 (23.26)	6 (33.33)	42 (30.66)
a tool which should contribute to solve societal issues	9 (11.84)	7 (16.28)	1 (5.56)	17 (12.41)
a communication tool aimed to promote and strengthen the organizations behind	0 (0.00)	0 (0.00)	1 (5.56)	1 (0.73)
Undecided	4 (5.56)	4 (9.30)	1 (5.56)	9 (6.57)
Total (n = 137)	76 (100.00)	43 (100.00)	18 (100.00)	137 (100.00)

Table 7: The perception of CS as measured by the variable q17att across PIICS status. n = 139

Question B illustrates the perceived role of CS projects. The results are shown in table 8. The findings are in-line with the earlier drawn conclusions. χ^2 testing revealed statistical dependence between PIICS status and CS project perception (as measured by Question B) at $\alpha = 0.05$.

Question B: Citizen science projects should first and foremost…	Professional involvement in CS projects? Column percentages are shown in parentheses			
	No	Yes, involved now	Yes, involved earlier	Total
Educate co-citizens	28 (36.84)	6 (13.95)	6 (33.33)	40 (29.20)
Contribute to recognized science	26 (34.21)	21 (48.84)	7 (38.89)	54 (39.42)
Promote the organization behind	0 (0.00)	1 (2.33)	0 (0.00)	1 (0.73)
Promote the career of the scientist behind	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Entertain the participants	0 (0.00)	0 (0.00)	1 (5.56)	1 (0.73)
Contribute to solving of important societal issues	18 (23.68)	12 (27.91)	3 (16.67)	33 (24.09)
Undecided	4 (5.26)	3 (6.98)	1 (5.56)	8 (5.84)
Total (n = 137)	76 (100.00)	43 (100.00)	18 (100.00)	137 (100.00)

Table 8: The perception of CS projects as measured by the variable q16role across PIICS status. n = 139.

39 % of the respondents considered scientific contributions to be the prime objective of CS projects. 29 % deemed educational aims to be most vital for CS-projects while 24 % considered societal problem-solving to be the main target for CS projects. One respondent regarded entertainment of participants to be the most important feature and no respondents valued scientist promotion highest. PIICS currently involved in CS projects valued scientific contributions relatively higher and education of co-citizens relatively lower than other respondents. This may be attributed to the fact that most PIICS were involved in CS in science institutions. The associations between organizational ties and CS-related attitude patterns will be examined in the following.

3.3.3 General attitudes towards CS projects within the sample

Attitudes were generally very favourable towards CS within the sample. Favourable opinions towards CS and CS projects were dominant across five themes of interest (participation, data, organization, societal impact and scientific impact). PIICS had generally very positive experiences with CS involvement. The entire review of attitude-tendencies can be found in Appendix 4.

For instance, 87 percent of respondents considered CS projects to have positive educational effects. 91 percent of the respondents believed that CS projects could collect valuable data. 49 percent of the respondents considered Danish CS projects to be well-developed. Within the sample, 80 percent agreed that CS projects could facilitate solution of societal problems, and 87 percent claimed that CS projects could have important scientific impact. As a relatively large proportion of the respondents were PIICS, those patterns are somewhat expected. The trend was the same, however, for all respondents regardless of professional associations to CS projects or voluntary status.

Significant differences in attitudes towards CS-related issues were observed across PIICS- and voluntary status. Notably, science institution-affiliated PIICS considered CS projects to have a significantly lower educational impact than other respondents (measured by the variable *p1*). On the other hand, science-institution affiliated PIICS believed CS data to be more reliable, valid and useable than other respondents (as measured by the variables *d2*, *d3* and *d6*). Public management-affiliated PIICS were significantly more positive towards potential societal impacts of CS projects as measured by the variables *i4* and *i5*. As measured by the variable *s5*, NGO-associated PIICS had significantly more favourable opinions towards the how CS-based research was recognized compared to other respondents. Interestingly, CS project volunteers deemed CS project recruitment to be easier than other respondents. This significant trend was measured by the variable *p5*. Group-related response patterns will be examined further in the following.

3.3.4 What matters? Ranking the most important criterions of success and challenges of CS projects

3.3.4.1 Comparison of criterions of success across CS involvement status

The ranking experiment revealed that different response groups valued CS project-related success-criteria differently. Namely, the affiliation of PIICS had a significant impact on ranking as measured by this experiment. CS project volunteers did not rank the below-listed criterions of success significantly different from respondents with no prior participation in CS projects.

For the entire sample, scientific impact was considered the most important criterion of success for a given CS project. High data quality was ranked second. Promotion of organizers was ranked lowest for all groups. The results are shown in table 9. Statistically significant differences from sample average rank at $\alpha = 0.05$ are marked with *.

Question C: What is the most important criterion for a CS project to be considered a success?	**Professional involvement in CS projects?**			
Criterion (Each parameter was ranked 1-7 by each respondent)	**Entire sample (n =125)** **Mean rank ± SD**	**PIICS in science institutions (n = 39)** **Mean rank ± SD**	**PIICS in NGOs (n = 26)** **Mean rank ± SD**	**PIICS in public management institutions (n = 7)** **Mean rank ± SD**
Scientific impact	2,68 ± 1,73	2.10 ± 1.54 *	2.84 ± 1.54	3.57 ± 1.99
High data quality	2,99 ± 1,73	2.74 ± 1.46	2.96 ± 1.73	4.14 ± 1.68
Participant educational gains	3,22 ± 1,57	3.13 ± 1.44	3.11 ± 1.58	2.71 ± 1.50
Important contributions to solve a major societal issue	3,37 ± 1,61	3.79 ± 1.49 *	3.15 ± 1.62	1.86 ± 1.21 *
Many participants	4,38 ± 1,71	4.56 ± 1.57	4.61 ± 1.72	4.28 ± 1.38
Influence on the political debate	4,94 ± 1,51	5.18 ± 1.54	4.54 ± 1.63	4.86 ± 1.86
Promotion of organizers	6,41 ± 1,16	6.48 ± 0.94	6.77 ± 0.51 *	6.57 ± 0.79

Table 9: Criterion of success as measured by im-variables across PIICS involvement. A low mean rank reflects high importance. n = 125. Undecided respondents are left out. Significant differences from sample mean identified by two-sample t-test are marked with *.

Notably, PIICS affiliated to science institutions valued scientific impact significantly higher than other respondents. Interestingly, science-affiliated PIICS considered “Important contributions to solve a major societal issue” to be significantly less important than other respondents. On the contrary, PIICS in public management valued “Important contribution to solve a major societal issue” the highest, and significantly higher compared to other response groups. As revealed in the interview of IP 3, CS projects has an instrumental role in some management strategies, as CS projects can increase public awareness and sustain effective monitoring. This might explain the high rank amongst public management-affiliated PIICS. Also, public-management-affiliated PIICS ranked scientific impact lower than other response groups, albeit not significantly lower. The potential schism between scientific and societal contributions of CS will be discussed in the following.

Surprisingly, NGO PIICS valued promotion of organizers significantly lower than other respondents. One might expect NGOs to value promotion higher, yet the finding is in line with the notion expressed by the NGO-affiliated IP 4 during the interview: That valuing promotion over other impacts would not be appropriate.

3.3.4.2 Comparison of perceived challenges across CS involvement status

Perceived challenges of CS projects varied significantly between groups when comparing means of different groups of PIICS to sample mean. No significant differences regarding CS project challenge perception (as measured by this ranking experiment) were observed when comparing CS project volunteers with respondents with no prior CS project participation.

Table 10 shows the perceptions of challenges within the sample. Statistically significant differences from sample average rank at $\alpha = 0.05$ are marked with *. The ranking-values varied a lot between respondents as indicated by the relatively high standard deviations compared to mean ranks. For the entire sample, “Low data quality” was considered the most important challenge for CS projects. Also, participation-related issues (e.g. lack of participants and inexpedient participant behaviour) were considered relatively important in all groups. Adding to what the qualitative analysis of interviews indicated, “lack of funding” was considered a relatively important challenge for CS projects, especially by science institution-affiliated PIICS and NGO-affiliated PIICS.

Question D: What poses the greatest challenges for CS projects?	Professional involvement in CS projects?			
Challenge (Each challenge was ranked 1-10 by respondents)	**Entire sample (n =100)** **Mean rank ± SD**	**PIICS in science institutions (n = 35)** **Mean rank ± SD**	**PIICS in NGOs (n = 23)** **Mean rank ± SD**	**PIICS in public management institutions (n = 6)** **Mean rank ± SD**
Low data quality	4,11 ± 3,09	4,77 ± 3,18	5,22 ± 2,91 *	3,00 ± 3,52
Inexpidient participant behavior	4,41 ± 2,87	4,63 ± 2,68	4,91 ± 3,01	4,33 ± 2,94
Few participants	4,73 ± 2,70	4,54 ± 2,89	5,17 ± 3,02	3,50 ± 2,51
Technical issues	4,77 ± 2,72	4,46 ± 2,68	4,35 ± 2,87	6,83 ± 2,04 *
Lack of funding	5,12 ± 2,96	4,49 ± 2,78	4,48 ± 3,16	5,50 ± 2,35
Little appriciation of participants	5,65 ± 2,76	5,06 ± 2,52	5,22 ± 2,80	5,17 ± 2,23
Lack of scientific recognition	5,92 ± 2,64	6,40 ± 2,68	6,39 ± 2,27	6,33 ± 2,94
Low educational gains among participants	6,55 ± 2,56	6,31 ± 2,42	5,91 ± 2,21	6,33 ± 3,72
Little contribution towards addressing societal issues	6,8 ± 2,41	7,03 ± 2,70	7,04 ± 3,07	6,00 ± 2,45
Little influence on political opinion-shaping	6,94 ± 2,35	7,31 ± 2,39	6,30 ± 2,60	8,00 ± 1,67

Table 10: CS project challenges as measured by pro-variables across PIICS involvement. A low mean rank reflects high importance. n = 120. Undecided respondents are left out. Significant differences from sample mean identified by two-sample t-test are marked with *.

NGO-affiliated PIICS ranked “Low data quality” significantly lower than other respondents. This may possibly imply one of two things: 1) That NGO-affiliated PIICS trust data quality or 2) that NGO-affiliated PIICS do not care about data quality. As revealed by the qualitative analysis, the first assumption is in line with the expressions made by the NGO-affiliated IP 4, as he claimed data quality to be high in all CS projects, he knew of. Also, 62 percent of PIICS with NGO-affiliation believed that data collected in CS projects was generally reliable and only 4 percent deemed it unreliable, as measured by the variable *d6*.

PIICS in public management institutions ranked “Technical issues” significantly lower than other respondents. This may be attributed to the fact that only one identified CS project was solely run by a public management institution (and technical administration was subcontracted), which may limit the technical experiences of this group. Conclusions drawn from this pattern should be cautious, though, given the small sample size.

Interestingly, only few respondents considered “Lack of scientific recognition”, “Low educational gains among participants”, “Little contribution towards addressing societal issues”, and “Little influence on political opinion-shaping” to be relatively important challenges for CS projects. Hence, one could argue that the main challenges for CS projects (as perceived by the respondents) does not regard potential impacts, but rather practical, sampling-related issues. This will be furtherly addressed in the discussion.

4. Discussion

4.1 The status of Danish citizen science

The analysis revealed a rich and somewhat diverse landscape of Danish CS projects, which must be understood within a wider international context of CS. CS is indeed becoming mainstream (Bonney et al. 2016). The majority of projects did however explore or monitor patterns of ecology, often with limited ways of public participation. It was also revealed that most projects were contributory *Conservation* – or *Investigation* projects, often organized by traditional science institutions or NGOs. Recently, several *Action* projects, *Virtual* projects and *Education* projects have been developed, which may indicate a general shift towards other project types, possibly with more sophisticated ways of including participants throughout the scientific process. Regardless, the landscape of CS projects is not static, as CS project stakeholders may value different aims, processes and values differently across time, space and organizational constraints (Eitzel et al. 2017).

Several identified projects were organized by grass-root communities unaffiliated with major CS developers. As traditional scientific values (e.g. high data quality, scientific leadership) were revealed as prime concerns in this study, potential impact, especially scientific impact, of such “grass-root” projects may be limited. It is an interesting discussion, as it situates CS perceptions within a larger debate on the role of science in society (Bucchi & Trench 2014). Should CS be considered a path-dependent, top-down-driven entity, or is CS an empowering, deliberative democratic movement (Greener 2018; Irwin 1995)?

The two strands of CS encapsulate the essence of this debate. On one end of the spectre, CS is essentially perceived as a scientific instrument (Eitzel et al. 2017; Bonney, Cooper, et al. 2009). This study provided empirical support for this perception to be the dominant as revealed by Questions A and B. On the other hand, it was generally recognized that CS projects could increase public awareness and facilitate learning and societal problem-solving. Thus, CS was also widely considered to be capacity building (Ceccaroni et al. 2017). Science institution-affiliated PIICS did however value scientific impact significantly higher than societal impact, which is notable, as many CS initiatives originates out of science institutions. This could have implications for the future development of CS projects, as potential scientific impact could be valued higher than potential societal, democratic impact (Kimura & Kinchy 2016). Yet it might not be meaningful to consider CS project aims to be a zero-sum game, as scientific impact, participant outcome and societal benefits may in fact be synergetic (Cigliano et al. 2015). As stated by Bonney et al. (2016), CS projects developers must however realise that CS project participation does not necessarily imply participant learning, civic action or societal impact. Altered attitudes about science depends on how participants reflect about their role in science. Consequently, to maximize scientific and societal impacts, participant outcome must be addressed via inclusion of learning-specific goals, learning materials and learning evaluations for any given CS project (Bonney et al. 2016).

Phillips et al. (2012) suggest that public participation in scientific research can be evaluated using a five-step logic model consisting of the following steps in order: Input, activities, outputs, outcomes and impact with each step influencing the next (Phillips et al. 2012). Haywood (2014) distinguishes between the *external* value of PPSR projects, which concerns data reliability and validity, and *internal* value of PPSR projects, which measures participant outcome. Empirical evidence from this study indicates that the prime concerns regarding CS projects fall within the input and activities categories; as noted, low data quality, lack of participants and inexpedient participant behaviour was deemed the most important challenges for CS projects. This may further underline that the status – and possibly potentials – of Danish CS must mostly be understood within an input-centred, instrumental context.

It is of utmost importance to state that this study is not a general normative valuation of instrumentalist CS versus capacity building CS. Each CS project poses its own scope and constraints. Therefore, valuing instrumentalist gains in contrast to capacity building efforts should first and foremost support fulfilment of project-specific intent and practises (Eitzel et al. 2017; Shirk et al. 2012). As revealed in the interviews, however, outcome and impact are often central criteria for funding, and hence facilitation of future CS projects. Connecting input to impact – e.g. via the strategies proposed by Bonney et al. (2016) – will be a continuous vital objective for Danish projects in the future. The qualitative analysis revealed that CS project developers were very aware of the importance of participant outcomes and societal impacts. Further implementation of guiding principles for CS, such as those proposed by ECSA, may contribute to sustaining synergetic relationships between scientific impact, participant outcome and societal gains in the future (ECSA 2015).

4.2 Towards a best practise: An instrumentalist perspective on CS potentials

In an instrumentalist perspective, the potential scientific impact of CS projects is largely influenced by their external quality (Cooper & Lewenstein 2016; Ceccaroni et al. 2017; Haywood 2014). As revealed by the qualitative and quantitative analysis, input-related issues were also prime concerns among interviewees and survey respondents. Hence it must be considered key objective to increase input quality. Several practises have been proposed to enhance the external quality.

In the traditional top-down perspective of citizen science, choosing the right scientific question is the first step for achieving high scientific impact. The scientific question can be viewed upon as a methodological constraint that influence patterns of participation, data-collection and hence potential scientific impact. Therefore, according to Bonney et al. (2009), the first step for CS projects should always be to establish a scientific question (Bonney, Cooper, et al. 2009). Yet as revealed in the interviews, all questions of scientific interest may not be suitable for CS-based research, as complicated projects can reduce participation, data-quality and scientific impact (Bonney, Cooper, et al. 2009; McKinley et al. 2017; Geldmann et al. 2014). Danish experiences supports this notion, as the now-ended CS projects “BIOWIDE” and “Projekt Skovmår” struggled with sampling biases because of complexity (Touveneau 2017). Considering that the scientific relevance of CS in an instrumentalist view is very dependent on its data-collecting capabilities, the varying degrees of participant abilities and public interest – and hence data-collection potential – poses a current and future challenge for CS (McKinley et al. 2017).

In the qualitative analysis, feedback-mechanisms were revealed to be valuable ways of motivating CS participants, as feedback increase participant outcome and public participation in CS. From the instrumentalist CS perspective, feedback mechanisms should therefore be considered as facilitators of high data quality, high data quantity and scientific impact (van der Wal et al. 2016). This practise is in line with the guiding principles for CS suggested by the ECSA, and as revealed by the qualitative analysis, CS project developers were very aware of maintaining high ethical standards regarding CS participation (ECSA 2015; Resnik et al. 2015)

As stated by Bonney et al. (2014) among others, standardized sampling procedures may greatly increase the validity and reliability of CS data (Bonney et al. 2014). Strict protocols regarding participant sampling procedures are often mentioned as being important drivers for acquiring high quality CS data, as they can increase data reliability and reduce the risk of sampling biases (Zuckerberg & McGarigal 2012; Bonney et al. 2014; Wiggins et al. 2011). The qualitative evidence suggest that quality-sustaining protocols are indeed deeply integrated into Danish CS projects. Furthermore, future developments of quality sustaining measures such as automatic photo recognition and community-based data validation schemes may further increase data quality of CS projects (Wiggins & He 2016; Wiggins et al. 2011). Participant evaluation-criteria such as those incorporated in "Punkttællingsprogrammet" could also increase the scientific recognition of CS data, as not all CS data is of similar quality. Separating the wheat from the chaff by establishing a knowledge-gradient could be beneficial for achieving high data quality, scientific embracement of CS and high scientific impact of CS projects (Elbroch et al. 2011). The progressive development of statistical analysis tools may also enhance CS data applicability and hence scientific impact in the future (Bird et al. 2014; Geldmann et al. 2016).

Top-down appliance of protocols may come at a cost, however, as adopting standardized protocols may inhibit the science-society dialogue, as such protocols originates out of professional scientific spheres and often diminishes the ways of public participation in CS (Couvet & Prevot 2015). This matter can be viewed upon as a normative trade-off between maximizing scientific validity versus maximizing science-society dialogue, as appliance of standardized top-down protocols may be considered a de facto acceptance of a deficit-relationship between science and society (Couvet & Prevot 2015; Bucchi & Trench 2014). On the other hand, applying certain quality-securing protocols may be an imperative necessity for CS to have scientific legitimacy from a traditional instrumentalist perspective: Without these scientific criteria for data-collection, there may not be a role for CS in science. And with no role of CS in science, CS projects cannot facilitate participant outcome or societal pact whatsoever (Bonney et al. 2014).

According to Bonney et al. (2001), project redundancy must avoided to maximize the scientific impact of CS projects (Bonney et al. 2014). Evidently, project redundancy was somewhat prevalent in Denmark, as multiple projects had similar scientific aims and methodologies. Bonney et al. (2014) suggest that CS project developers and scientists organize to minimize project redundancy. Notably, the qualitative analysis revealed that CS project developers shared this opinion. Future organization and cooperation may be facilitated by launching of partnership-driven umbrella initiatives such as "Artsportalen" and CS project portals such as "citizenscience.dk". Future CS project cooperation and integration must however address project ownership and data ownership, especially when considering how close CS and open-science are potentially interconnected (Szkuta & Osimo 2016).

Developing a best practise for CS in an instrumentalist view should always take into account the project-specific needs and constraints, yet it should be considered a general imperative to connect input to impact (Shirk et al. 2012; Phillips et al. 2012). However, as noted by Theobald et al. (2015), the scientific impact of CS is largely dependent on how CS is embraced by and integrated into traditional scientific research agendas. In order to maximize the scientific impact of CS projects, CS must be embraced by established scientific communities – which is also increasingly is, according to the qualitative evidence (Theobald et al. 2015; Ceccaroni et al. 2017). As revealed by this study, creating scientifically sound synergies between project developers and project participants is the prime objective for establishing CS as an acknowledged instrument of scientific inquiry in Denmark (McKinley et al. 2017; Bonney et al. 2014).

4.3 From crowdsourcing to deliberation: Realizing the civic potentials of citizen science

This study revealed that participant outcomes and societal impact were highly regarded when it comes to the role and potentials of CS. According to the evidence, CS can promote learning, alter attitudes, stimulate public engagement, legitimize science and science institutions, legitimize management practises and management institutions and overall increase the knowledge-base for civic action. Thus, CS was widely considered to be capacity-building.

Capacity building CS can be small-scale, e.g. individual learning, and large-scale, e.g. development of democratic scientific citizenship and institutions (Phillips et al. 2012; Ceccaroni et al. 2017; Irwin 2015). In the following, the potentials of capacity building CS will be discussed according to these different scales. It must however be noticed that individual outcomes of CS participation greatly influence potential large-scale impacts (Phillips et al. 2012).

The qualitative evidence suggest that CS projects hold greats potentials for promoting science education. The research collaboration between amateurs and scientists facilitated participant learning; as revealed, collecting and analysing authentic data attributed to a larger scientific understanding among participants, and recognition from professional scientist were very fruitful for participant motivation. Importantly, CS can be integrated in both formal and informal education across many educational levels (Bonney, Ballard, et al. 2009; Henderson et al. 2012; Dunn & Menninger 2016).

Mitchell et al. (2017) found that a teaching strategy that combined CS with inquiry-based learning increased participants understanding of their role in science and spurred engagement regarding environmental issues (Mitchell et al. 2017). Namely connecting CS to inquiry-based science education (IBSE) holds great potentials for increasing the learning outcome among CS participants. As student-driven inquiry is fundamental in IBSE, investigation of real-life patterns and objects of interest could provide a knowledge base for contributory CS projects while also promoting several key competencies among students (Frisdahl et al. 2014). From an IBSE perspective, the positive learning impacts would likely be even higher in co-created or collaborative CS projects, as students can create, investigate and evaluate their own hypotheses in such projects (Frisdahl et al. 2014; Bonney, Ballard, et al. 2009). From an IBSE standpoint, top-down-led, data-centred with CS projects rigorous protocols may therefore be less fruitful for science education than bottom-up, participant-oriented CS projects. This may imply that a normative trade-off between scientific usability and participant education does sometimes exist for CS projects (Davies & Horst 2016). On the other hand, given the evidence, "Real Science - DNA og Liv" could rightfully be considered a Danish model example of how to synergistically integrate scientifically sound CS practices with successful science education.

Nature History Museums (NHMs) were responsible for a large proportion of the Danish CS projects. This is in congruence with the findings of Ballard et al. (2017), who deem NHMs to be natural focal points for bridging conservation and science education through CS (Ballard et al. 2017). The CS activities of Danish NHMs underlines that bridging science to society is increasingly important. Consequently, CS should be considered a prime mean for science communication (Davies & Horst 2016; Bucchi & Trench 2014; Ballard et al. 2017). The ability of capacity building CS projects to foster dialogue, drive public engagement and legitimize science cannot be underestimated (Bucchi & Trench 2014; Theobald et al. 2015).

Several studies reveals that CS participation leads to altered attitudes and engagement, yet Danish research on the matter is scarce (Branchini et al. 2015; Johnson et al. 2014). The evidence provided by this study does indeed indicate that CS participation can influence patterns of attitudes and engagement. CS project-facilitated learning efforts can alter attitudes, but as noted by Jordan (2012), in order to be engaged in decision-making, CS participants must be motivated and feel that their actions matter (Jordan et al. 2012).The qualitative evidence suggest that Danish CS developers are very aware of this. Sustaining participant motivation and thus maximizing potential engagement is vital for current and future CS projects, especially given the necessity of handling global issues on a local scale (Theobald et al. 2015).

From a capacity building CS perspective, CS can increase personal enlightenment, community formation and facilitate development of democratic and scientific societal institutions; thus, CS participation may be a mean for deliberation (Davies & Horst 2016). The evidence provided by this study suggest that this notion is widely accepted among CS developers and members of the public. To further evolve CS as a capacity building entity however, CS must address the concerns of citizens in an inclusive fashion (Couvet & Prevot 2015; Davies & Horst 2016; Irwin 1995).

Evidently, many CS projects did not follow these practises, as many projects would investigate questions of niche scientific interest rather than matters of obvious public concern. As noted by IP 3, such knowledge - and interest asymmetries may exist between CS project developers and CS project participants. Moreover, many projects resembled crowdsourcing rather than collaboration, as citizen participation was often limited to data-collection. One might argue that understanding niche scientific questions are in fact a matters of public interest; that monitoring the distribution of hoverflies may facilitate understanding of biodiversity patterns, which may be of public interest considering the environmental crises, we are facing (Theobald et al. 2015). At the very least, however, considerable communication efforts should be made – and are being made in some project regimes – to promote the public understanding of CS in order legitimize science and facilitate public engagement and governance (Couvet & Prevot 2015; Davies & Horst 2016; Theobald et al. 2015). CS can increase public understanding of science, but it can also alter the scientific understanding of the public (Irwin 1995). In the future, CS can transform the science-society relationship and promote dialogue and public engagement, which is increasingly important if the time of the ivory tower is truly over.

5. Conclusion

This study reveals that the landscape of Danish CS projects is rich as 55 running projects were identified. Most Danish CS projects are contributory *Conservation* or *Investigation* projects, however, and public inclusion in CS projects is often limited to data-collection. The landscape of CS projects and the attitudes and preferences among CS project developers reflects that CS in Denmark is mostly an instrumentalist, top-down, input-centred entity.

Relatively few organizations were responsible for a large part of the Danish CS projects, which may cause path-dependency to play a role in future development of CS projects. Many projects were organized by science institutions and NGOs, which may imply that the CS projects are often developed to serve the interest of such organisations. Specifically, project developers were very concerned about sustaining the scientific status of CS projects. This may cause developers to value e.g. data quality higher than participant outcome and potential societal impacts, which is logical given that CS is a relatively new and radically distinct scientific entity. Hence, scientific embracement of

CS requires strong scientific impact which must be sustained via sound scientific practises. Yet it might not always be reasonable to consider the project-specific valuation scientific impact versus societal impact to be a normative trade-off; if properly developed and communicated, CS projects may synergistically satisfy scientific goals while achieving small-scale and large-scale civic impact.

Regardless, CS project developers should be very aware that CS projects should always take context-specific constraints into account and make their aims and values clear. Connecting input to impact remains the key challenge for CS. As new, wide-spread technologies increase the possibilities for public participation in science, CS project developers should strive to include the public in more scientific processes within CS project regimes, as it might lead to scientific enhancements and increased civic impact. As recognized by CS project developers, CS is a key facilitator of science-society dialogue, legitimation of science, civic education and engagement – and ultimately deliberation and development of scientific citizenship.

The analytical focal point of this study has been on the development side of CS projects. Future (Danish) studies should examine how participants shape CS projects, as the status and potentials of CS projects depends on patterns of participation. Also, the societal impact (in a wide-sense) of CS projects has not been investigated scientifically in Denmark. As potential societal impact is key for facilitating CS projects, e.g. in terms of funding and public outreach, the real-life impacts of CS projects should be documented to further legitimize future CS projects.

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Appendix

Appendix 1: Interview protocol

This in an example of the used interview protocols. This was used for interviewing IP 2. The interview was held in Danish. Questions are not translated.

INTERVIEWGUIDE: (Marie Lillemark, SNM, REAL SCIENCE - DNA og Liv)

BAGGRUND:
Kan du sige lidt om dig selv, og de projekter du har været involveret i?
Hvordan vil du beskrive den organisation, der står bag REAL SCIENCE – DNA og Liv?
Hvilke formål har SNM?
Hvad forstår du - og SNM - ved CS?
Hvordan bruger SNM CS-projekter
Hvorfor bruger SNM CS?
Hvilken effekt oplever du - og dine kolleger - at CS har for jeres organisation?
Hvilke styrker og svagheder ser du i brugen af CS i jeres organisation?
Hvordan bidrager CS-projekter til organisationens formål?
Hvad er vigtigt for at I som organisation fører et potentielt CS-projekt ud i livet?
Hvordan vil du beskrive citizen science som videnskab?
Hvilke styrker og svagheder ser du i brugen af CS generelt?

FORMÅL
Kan du fortælle lidt om tilblivelsen af CS-projektet REAL SCIENCE / DNA og Liv?
Hvilke(t) formål har CS-projektet REAL SCIENCE – DNA og Liv?
Hvem står bag CS-projektet? Hvordan opstod idéen? Hvorfor er der behov for dette projekt?
Hvordan ledes CS-projektet?
Hvordan anvendes teknologi i CS-projektet?
Trækker I på erfaring fra andre projekter? Hvordan?
Har projektet ændret karakter over tid? Hvordan
Er projektet en succes? Hvorfor/hvorfor ikke?

FINANSIERING
Hvordan finansieres projektet?
Hvordan forholder det sig med finansiering af CS-projekter generelt (i jeres organisation)?
Er det nemt at få finansieret CS-projekter?

DATA
Hvad bruger I projektets data til?
Har andre brugt jeres data – eller jeres konklusioner? Hvordan?
Har andre brugt jeres data fra andre projekter? Hvordan?
Hvordan vurderer du datakvaliteten i dette projekt / jeres projekter generelt?
Hvordan sikrer I datakvaliteten i dette projekt / jeres CS-projekter generelt?
Hvad er vigtigst, megen data eller pålidelig data?

DELTAGERE
Hvor mange deltagere er der i projektet?
Kan du beskrive den typiske deltager i dette CS-projekt - og jeres projekter generelt? / Hvem er de typiske deltagere?
Kræver det noget at kunne deltage i dette projekt / jeres CS-projekter generelt?
Hvordan inddrages deltagerne i dette projekt?
Er deltagere og målgruppe den samme gruppe?
Hvorfor deltager folk i dette projekt?
Hvordan rekrutteres deltagere til dette projekt og jeres CS-projekter generelt?
Er det ofte de samme brugere, der deltager i flere af jeres projekter?
Udvælger I konkret hvem der får lov at deltage i projekter - hvordan?
Hvordan uddannes deltagere – hvis de uddannes?
Er uddannelse en forudsætning for deltagelse?
Hvad er deltagerne gode og mindre gode til ift. dette projekt/projekter generelt?
Hvad påvirker deltagernes motivation for deltagelse? Konkrete eksempler?
Hvad oplever deltagerne som motiverende/demotiverende?
Hvordan motiverer I deltagerne til at fortsætte deltagelsen?
Belønner i deltagere? Hvordan?
Er læring hos deltagerne et selvstændigt mål? Hvorfor/hvorfor ikke?
Hvad får deltagerne ud af deltage i jeres CS-projekter? Har I undersøgt det? Konkrete erfaringer?

PRIORITERINGS ØVELSE:

Jeg vil her bede dig om at prioritere mellem følgende, selvom det nok kan være svært:

Høj datakvalitet >< Stort læringsudbytte for deltagerne >< Stort impact – f.eks. videnskabeligt eller forvaltningsmæssigt.

Hvad er vigtigst for dette projekt? Er det forskelligt fra andre projekter her? Hvorfor?

FREMTID:
Hvordan ser du fremtiden for CS-projekter i jeres organisation?
Hvordan ser du fremtiden for CS-projekter generelt?
Har I konkrete planer om CS-projekter? Hvilke?
Hvad ser du som de største potentialer for CS? Hvordan skal disse potentialer realiseres?
Hvilke udfordringer er de største for CS? Hvordan bør man imødegå dem?
Har du nogen afsluttende kommentarer?

Appendix 2: Survey

The survey was conducted in Danish. Questions are not translated. Please notice that questions 18 and 19 were ranking exercises that does not translate well from SurveyXact to Microsoft Word.

Intro

Kære deltager.

Tak fordi du har lyst til at bidrage til mit specialeprojekt om citizen science og citizen science-projekter i Danmark. Jeg er dig meget taknemmelig for, at du vil hjælpe mig med undersøgelsen.

Citizen science, undertiden kaldet borgervidenskab, kan defineres som "inddragelse af borgere i den videnskabelige proces, hvor de bidrager til at løse problemer fra den virkelige verden". Der findes en bred vifte af meget forskelligartede citizen science-projekter.

I dette spørgeskema skelnes der mellem "tilrettelæggere" og "deltagere". "Tilrettelæggere" er de personer, der designer, koordinerer, formidler eller evaluerer projektet. "Deltagere" angiver de borgere, der deltager (frivilligt) i projektet.

Spørgeskemaet kan besvares anonymt og tager 8-10 minutter at besvare. Personhenførbar data (eksempelvis oplysninger om beskæftigelse) vil ikke blive delt med andre.

Der vil komme enkelte spørgsmål om din baggrund samt spørgsmål om din holdning til citizen science og citizen science-projekter.
Hvis der er spørgsmål, du ikke ønsker at besvare, har du altid mulighed for at vælge svaret "Jeg har ikke lyst til at svare".

Tak for din deltagelse,

Christian Stolt
Specialestuderende, Institut for Naturfagenes Didaktik, Københavns Universitet
Email: cts766@alumni.ku.dk

1. Hvad er din alder?

__

2. Hvad er din højest gennemførte uddannelse?

(1) ❑ Grundskoleuddannelse
(2) ❑ Gymnasiel uddannelse
(3) ❑ Kort videregående uddannelse
(4) ❑ Erhvervsfaglig uddannelse
(5) ❑ Mellemlang videregående uddannelse
(6) ❑ Bacheloruddannelse
(7) ❑ Længerevarende videregående uddannelse, herunder kandidatuddannelser
(8) ❑ Forskeruddannelse (Ph.d.-uddannelse)
(9) ❑ Længere end Ph.d.-uddannelse (eksempelvis professorater)
(10) ❑ Andet, angiv _____
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

3. Hvad er din nuværende stilling og arbejdsplads?

(1) ❑ Stilling, anfør venligst: _____
(2) ❑ Arbejdsplads, anfør venligst: _____
(3) ❑ Jeg er uden for arbejdsmarkedet
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

4. Hvordan vil du vurdere dit kendskab til danske citizen science-projekter?

(1) ❑ Meget dårligt
(2) ❑ Dårligt
(3) ❑ Hverken dårligt eller godt
(4) ❑ Godt
(5) ❑ Meget godt
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

4.1 Har du været frivillig deltager (ikke tilrettelægger) i citizen science-projekter?

(1) ❑ Ja, anfør gerne hvilke: _____
(2) ❑ Nej
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

5. Er du eller har du tidligere været involveret i tilrettelæggelsen af citizen science-projekter?

(1) ❑ Ja, er involveret nu
(2) ❑ Ja, har tidligere været involveret, men er det ikke længere
(3) ❑ Nej
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

6. Hvordan har du været involveret i citizen science-projekter som tilrettelægger? Sæt gerne flere krydser.

(1) ❑ I forbindelse med den videnskabelige tilrettelæggelse af projektet
(2) ❑ I forbindelse med den formidlingsmæssige tilrettelæggelse af projektet
(3) ❑ I forbindelse med rekrutteringen af deltagere
(4) ❑ I forbindelse med den praktiske koordinering af projektet
(5) ❑ I forbindelse med formidlingen af projektet
(6) ❑ I forbindelse med evalueringen af projektet
(7) ❑ I forbindelse med den videnskabelige efterbehandling af projektet
(8) ❑ Andet, beskriv gerne _____
(9) ❑ Jeg har ikke været involveret i citizen science-projekter
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

7. Har du lyst til at oplyse, hvilke citizen science-projekter, du har været involveret i som tilrettelægger?

(1) ❑ Ja
(2) ❑ Nej

8. Hvilke citizen science-projekter har du været involveret i som tilrettelægger?

Du bedes kun angive de projekter, hvor du har været aktiv tilrettelægger. Du bedes ikke angive projekter, hvor du har været almindelig deltager

Anfør gerne: ______________________________

Anfør gerne: ______________________________

Anfør gerne: ______________________________

9. I hvilke typer af organisationer har du været involveret i citizen science-projekter?

Angiv venligst i hvilke organisationer

(1) ❑ Forsknings-, uddannelses- og formidlingsinstitutioner, eksempelvis universiteter og museer

(2) ❑ Interesseorganisationer, eksempelvis foreninger

(3) ❑ Offentlige institutioner, eksempelvis kommuner og styrelser

(4) ❑ Private virksomheder, herunder fonde

(5) ❑ Andre, angiv gerne ______

(6) ❑ Jeg har ikke været involveret i citizen science-projekter

(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

10. Hvilke af følgende termer beskriver bedst din oplevelse ved at være involveret i et eller flere citizen science-projekter? Sæt max 5 krydser.

(1) ❑ Motiverende

(2) ❑ Demotiverende

(3) ❑ Inspirerende

(4) ❑ Deprimerende

(5) ❑ Anerkendelsesværdigt

(6) ❑ Hasarderet

(7) ❑ Udbytterigt

(8) ❑ Langsommeligt

(9) ❑ Kedeligt

(10) ❑ Fagligt udfordrende

(11) ❑ Fagligt udviklende

(12) ❑ Uinspirerende

(13) ❑ Overflødigt

(14) ❑ Ødelæggende

(15) ❑ Nyskabende

(16) ❑ Visionært

(17) ❑ Uproduktivt

(18) ❑ Produktivt

(99) ❑ Ved ikke /Jeg har ikke lyst til at svare

De næste spørgsmål omhandler din holdning til citizen science og citizen science-projekter.

11. Disse spørgsmål omhandler din holdning til deltagerne i citizen science-projekter

Deltagere

	Meget uenig	Uenig	Hverken enig eller uenig	Enig	Meget enig	Ved ikke / Jeg ønsker ikke at svare
Deltagerne i citizen science-projekter får et vidensmæssigt udbytte	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter bidrager til at uddanne befolkningen	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Deltagelse i citizen science-projekter afhænger først og fremmest af borgerens interesser	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Deltagerne i citizen science-projekter er dygtige til at bidrage til projekterne	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Det er nemt at rekruttere deltagere til et citizen-science projekt	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑

12. Disse spørgsmål omhandler din holdning til citizen science-data

Data

	Meget uenig	Uenig	Hverken enig eller uenig	Enig	Meget enig	Ved ikke / Jeg ønsker ikke at svare
Data indsamlet i citizen science-projekter er af lav kvalitet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter kan indsamle værdifuld data	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Data indsamlet i citizen science-projekter er generelt mere upålidelig end data indsamlet på traditionel vis	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Det er dyrt at indsamle data i citizen science-projekter sammenlignet med traditionelle forskningsprojekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Det er tidskrævende at indsamle data i citizen science-projekter sammenlignet med traditionelle forskningsprojekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Data indsamlet i citizen science-projekter er generelt troværdig	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑

13. Disse spørgsmål omhandler din holdning til organiseringen af citizen science-projekter

Organisering

	Meget uenig	Uenig	Hverken enig eller uenig	Enig	Meget enig	Ved ikke / Jeg ønsker ikke at svare
De fleste citizen science-projekter er afhængige af den nyeste teknologi	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Det er nemt at få finansieret citizen science-projekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
De fleste danske citizen science-projekter er veltilrettelagte	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter bør altid ledes af forskere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Deltagerne i et citizen science projekt bør inddrages i alle projektets faser	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter bør altid tilrettelægges af interesse-organisationer	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter bør altid tilrettelægges af forsknings-insitutioner	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑

14. Disse spørgsmål omhandler din holdning til citizen science-projekters rolle i samfundet

Citizen science og samfundet

	Meget uenig	Uenig	Hverken enig eller uenig	Enig	Meget enig	Ved ikke / Jeg ønsker ikke at svare
Citizen science-projekter kan have en stor politisk betydning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter kan have en stor videnskabelig betydning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter kan bidrage til at løse væsentlige samfundsudfordringer	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter har indflydelse på de politiske beslutningstagere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter forbinder den videnskabelige verden med resten af samfundet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter er en meningsfuld måde at få almindelige mennesker til at interessere sig for videnskaben	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑

15. Disse spørgsmål omhandler din holdning til citizen science-projekter og forskning

Citizen science og forskning

	Meget uenig	Uenig	Hverken enig eller uenig	Enig	Meget enig	Ved ikke / Jeg ønsker ikke at svare
Forskningsverdenen er generelt mistroisk overfor forskning, der er baseret på citizen science-projekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Det er vanskeligt at få publiceret videnskabelige artikler, der er baseret på citizen science-projekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter kan bruges i alle videnskabsgrene	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Forskning baseret på citizen science-projekter er andenrangsforskning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Forskning baseret på citizen science-projekter er anerkendt	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Forskningsprojekter, der inddrager citizen science, er nemmere at få finansieret end forskningsprojekter, der ikke gør	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
Citizen science-projekter kan besvare vigtige videnskabelige spørgsmål	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑
I fremtiden bør mere forskning være baseret på citizen science-projekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(99) ❑

16. Hvilket af følgende udsagn er du mest enig i?

Citizen science-projekter skal først og fremmest...

(1) ❑ ... uddanne medborgerne
(2) ❑ ... bidrage til anerkendt forskning
(3) ❑ ... fremme den organisation, der står bag
(4) ❑ ... fremme den enkelte forskers karriere
(5) ❑ ... underholde deltagerne
(6) ❑ ... bidrage til at løse samfundsproblemer
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

17. Hvilket af følgende udsagn afspejler bedst din holdning til citizen science?

(1) ❑ Citizen science er et videnskabeligt instrument, der skal indsamle data til forskerne
(2) ❑ Citizen science er et dannelsesprojekt, der skal uddanne og involvere befolkningen
(3) ❑ Citizen science er et værktøj, der skal bidrage til at løse samfundets udfordringer
(4) ❑ Citizen science er et kommunikationsredskab, der skal promovere og styrke de organisationer, der står bag
(99) ❑ Ved ikke / Jeg har ikke lyst til at svare

18. Hvad er vigtigst for at et citizen science-projekt kan betragtes som en succes?

Her bedes du rangere følgende udsagn efter hvad der er vigtigst. Den vigtigste skal øverst. Hvis du ikke ønsker at besvare spørgsmålet bedes du sætte "Ved ikke / Jeg ønsker ikke at besvare spørgsmålet" øverst.

	1	2	3	4	5	6	7	8
Høj datakvalitet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Mange deltagere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Læring hos deltagerne	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Stor betydning på den politiske dagsorden	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Stort videnskabeligt bidrag	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Betydningsfuldt bidrag til at løse et væsentligt samfundsproblem	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Promovering af den organisation eller de personer, der står bag projektet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑
Ved ikke / Jeg har ikke lyst til at svare	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑

19. Hvilke udfordringer er størst for citizen science-projekter?

Her bedes du rangere udfordringerne efter hvilke der er størst. Den største udfordring skal øverst. Hvis du ikke ønsker at besvare spørgsmålet bedes du sætte "Ved ikke / Jeg ønsker ikke at besvare spørgsmålet" øverst

	1	2	3	4	5	6	7	8	9	10	11
Lav datakvalitet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Mangel på deltagere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Deltagere, der ikke agerer i overensstemmelse med projekternes hensigt	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Manglende finansiering	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Lav anerkendelse i forskningsverdenen	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Lavt læringsudbytte for deltagerne	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Tekniske udfordringer	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Ringe betydning på den politiske dagsorden	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Manglende anerkendelse af deltagernes indsats	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Ringe bidrag til at løse væsentlige problemer	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑
Ved ikke / Jeg ønsker ikke at besvare spørgsmålet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑	(10) ❑	(11) ❑

Må jeg kontakte dig, hvis jeg har spørgsmål

(1) ❑ Ja, hvad er dit navn og email? _____

(2) ❑ Nej

Appendix 3: Identified CS projects

Action projects:

Project Name	Type by Bonney et al. (2009)	Description	Main organisation and partners
Et sundere Fyn (Syddansk Universitet 2018c; TV2 Fyn 2018)	co-created	Active involvement in local health-related decision-making	University of Southern Denmark; Odense University Hospital; TV2 Fyn
Campus Odense – Active Living (Syddansk Universitet 2018b)	co-created	Active involvement in local health-related issues; promotion of healthy lifestyles	University of Southern Denmark; University College Lillebælt; Odense University Hospital; Odense Municipality

Table 11: The list of identified running Action projects according to the typology offered by Wiggins and Crowston (2011).

Conservation projects:

Project Name	Type by Bonney et al. (2009)	Description	Main organisation and partners
DOFbasen (Dansk Ornitologisk Forening 2018a)	contributory	Country-wide bird monitoring	BirdLife Denmark
Projekt Ørn (Dansk Ornitologisk Forening 2018b)	contributory	Country-wide bird monitoring	BirdLife Denmark
Punkttællings-programmet (Dansk Ornitologisk Forening 2018c)	contributory	Country-wide bird monitoring	BirdLife Denmark
Havlitund-ersøgelsen (Sørensen 2016)	contributory	Country-wide species-specific game species monitoring	Danish Hunter's Association
Kæbeindsamlingen og Tandsnit-projektet (Danmarks Jægerforbund 2018b)	contributory	Country-wide red deer monitoring	Danish Hunter's Association; Ministry of Environment and Food of Denmark
Indberetning-sportalen - Invasive Arter (Miljøstyrelsen 2018)	contributory	Invasive species monitoring	Ministry of Environment and Food of Denmark

Vildtudbyttes-tatistikken (Christensen 2018a)	contributory	Country-wide game species monitoring	Ministry of Environment and Food of Denmark; Aarhus University - DCE
Fangstjournalen (DTU Aqua 2018b)	contributory	Country-wide monitoring of fish species through sport-fishing	Technical University of Denmark - Aqua
Undersøgelser af pighvar i Roskil-de fjord (Svendsen et al. 2017)	contributory	Local fish monitoring	Technical University of Denmark Aqua, local fish-ing association
Undersøgelse af vandring hos havørred i Roskilde Fjord (DTU Aqua 2017; Svendsen 2017)	contributory	Local fish monitoring	Technical University of Denmark Aqua; Fishing Zealand; local fishing asso-ciations
Fredningstjek (Danmarks Naturfredningsfor ening 2018c)	contributory	Country-wide conservation monitoring	The Danish Society for Nature Conservation
Naturtjek (Danmarks Naturfredningsfor ening 2016a)	contributory	Country-wide biodiversity monitoring through indica-tor species	The Danish Society for Nature Conservation; Natu-ral History Museum of Denmark; Aarhus Universi-ty - DCE
NaturDok (DCE 2018)	contributory	Country-wide documenta-tion of conservation initia-tives	Aarhus University - DCE
Vingeundersøgel-sen (Christensen 2018b)	contributory	Country-wide game species monitoring	Aarhus University - DCE; Ministry of Environment and Food of Denmark
Ringmærknings-centralen (Zoologisk Museum 2005; Statens Naturhistoriske Museum 2018i)	contributory	Country-wide monitoring of bird species	Natural History Museum of Denmark; Ministry of En-vironment and Food of Denmark; EURING; Dan-ish Ringing Assoiciation
Markvildtind-satsen (Danmarks Jægerforbund 2018a)	collaborative	Country-wide conservation initiatives	Danish Hunter's Associa-tion
Floratjek (Danmarks Naturfredningsfor ening 2018a)	collaborative	Country-wide conservation monitoring	The Danish Society for Nature Conservation

Table 12: The list of identified running Conservation projects according to the typology offered by Wiggins and Crowston (2011)

Investigation projects:

Project Name	**Bonney et al. (2009) type**	**Description**	**Main organisation and partners**
Krebseatlas (Astacon.dk 2018)	contributory	Country-wide taxon-specific atlas (crayfish)	Astacon; Natural History Museum of Denmark
Hvaler.dk (Kinze 2018)	contributory	Country-wide taxon-specific atlas (whales and seals)	Carl Kinze
Bioblitz (Statens Naturhistoriske Museum 2018e; Statens Naturhistoriske Museum 2018a; Sørensen et al. 2016)	contributory	Possibly concept rather than project; country-wide biodiversity exploration	Concept rather than project. Organized by several institutions, including the Natural History Museum of Denmark
InsektObs - Fynske Insekter (Fynske Insekter 2016)	contributory	Local insect monitoring	Entomological Society of Funen
Insectcount.dk (Insectcount.dk 2018)	contributory	Country-wide exploration of insect diversity	Insectcount.dk
Bugbase (Bugbase.dk 2018; Lepidopterologisk Forening 2018)	contributory	Country-wide monitoring of insect diversity	Lepidopterological Society
Myrejagten (Statens Naturhistoriske Museum 2018g)	contributory	Country-wide exploration of ant diversity through participant experimental sampling	Natural History Museum of Denmark
Insektmobilen (Statens Naturhistoriske Museum 2018f)	contributory	Country-wide exploration of insect diversity through participant sampling	Natural History Museum of Denmark
Danekræ (Statens Naturhistoriske Museum 2018b)	contributory	Country-wide collection of fossils	Natural History Museum of Denmark; Natural History Museum, Aarhus
Fiskeatlas (Statens Naturhistoriske Museum 2015; Statens Naturhistoriske Museum 2018h; Statens Naturhistoriske Museum 2018d)	contributory	Country-wide taxon-specific atlas (fish); consists of freshwater- and saltwater sub-projects	Natural History Museum of Denmark; Technical University of Denmark Aqua; Krog Consult
Projekt Glatsnogen (Naturhistorisk Museum 2018b)	contributory	Country-wide search for a possibly extinct species	Natural History Museum, Aarhus

Atlas over Danmarks ulve (Naturhistorisk Museum 2018a)	contributory	Country-wide taxon-specific atlas (wolves)	Natural History Museum, Aarhus; DCE - Aarhus University; Naturbasen Aps
Atlas over Danmarks Padder og Krybdyr (Naturbasen ApS 2018e)	contributory	Country-wide taxon-specific atlas (amphibians and reptiles)	Natural History Museum, Aarhus; Naturbasen Aps
Atlasprojektet Danmarks Karplanter (Naturbasen ApS 2018a)	contributory	Country-wide taxon-specific atlas (plants)	Naturbasen Aps
Atlasprojektet Danmarks Biller (Naturbasen ApS 2018b)	contributory	Country-wide taxon-specific atlas (beatles)	Naturbasen Aps
Atlasprojetet Danmarks Svirrefluer (Naturbasen ApS 2018f)	contributory	Country-wide taxon-specific atlas (hoverflies)	Naturbasen Aps
Naturbasen – Fugle og Natur (Naturbasen ApS 2018g)	contributory	Country-wide database of all species	Naturbasen Aps
Atlasprojektet Danmarks Guldsmede (Naturbasen ApS 2018d)	contributory	Country-wide taxon-specific atlas (dragonflies)	Naturbasen Aps, Natural History Museum, Aarhus; Aarhus University
Atlasprojektet Danmarks Sommerfugle (Naturbasen ApS 2018c)	contributory	Country-wide taxon-specific atlas (butterflies)	Naturbasen Aps; Natural History Museum, Aarhus; Aarhus University
Nøglefisker (DTU Aqua 2018a)	contributory	Country-wide monitoring of fish species through sport-fishing	Technical University of Denmark - Aqua
Ulvetracking.dk (Ulvetracking Danmark 2018)	contributory	Country-wide taxon-specific observation gathering (wolves)	Ulvetracking.dk; Natural History Museum of Denmark; Ministry of Environment and Food of Denmark
Svampeatlas 2.0 (Heilmann-Clausen et al. 2018)	collaborative	Country-wide taxon-specific atlas (fungi)	Natural History Museum of Denmark; MycoKey; Danish Mycological Society
Biologigaragen (Biologigaragen 2018)	co-created	Umbrella-organization facilitating development of CS initiatives	Biologigaragen

Table 13: The list of identified running Investigation projects according to the typology offered by Wiggins and Crowston (2011)

Virtual projects

Project Name	**Bonney et al. (2009) type**	**Description**	**Main organisation and partners**
Science At Home: Quantum Moves (Science At Home 2018d)	contributory	Virtual gamified investigation of quantum mechanics	Aarhus University
Science At Home: Quantum Minds (Science At Home 2018a; Science At Home 2018c)	contributory	Virtual gamified investigation of quantum mechanics	Aarhus University
Science At Home: Turbulence (Rafner 2018)	contributory	Virtual gamified investigation of physics	Aarhus University
Science At Home: Alien Game (Vuculescu 2018)	contributory	Virtual gamified investigation of cognitive science	Aarhus University
Science At Home:- Skill Lab: Science Detective (Nejsum & Behrendt 2018; Science At Home 2018b)	contributory	Virtual gamified investigation of cognitive science	Aarhus University; DR
Dansk Demografisk Database (Rigsarkivet 2018b)	collaborative	Virtual collection and digitalization of historic demographical data	The Danish National Archives
Rigsarkivets indtastningsportal (Rigsarkivet 2018a; Rigsarkivet 2018c)	collaborative	Virtual collection and digitalization of historical data	The Danish National Archives
Ageguess (Ageguess.org 2018)	collaborative	Virtual investigation of ageing patterns based on user-provided data	University of Southern Denmark

Table 14: The list of identified running Virtual projects according to the typology offered by Wiggins and Crowston (2011)

Education projects:

Project Name	Bonney et al. (2009) type	Description	Main organisation and partners
Masse-Eksperimentet (Astra 2018)	collaborative	Combined education (elementary school-level) and data-gathering (bacteria)	Astra; Aarhus University Hospital; Novozymes
Real Science - DNA og Liv (Statens Naturhistoriske Museum 2018c)	collaborative	Combined education (upper high school-level) and data-gathering (eDNA)	Natural History Museum of Denmark
Den store plantejagt (Friluftsrådet 2018)	collaborative	Combined education (elementary school-level) and data-gathering (plant observations)	Outdoor Council
Borgerdrevet journalistik (Syddansk Universitet 2018a)	collaborative	Combined education (several target groups) and data-gathering (journalism)	University of Southern Denmark
Opdag Havet 2.0 (WWF Denmark 2018)	co-created	Combined education (mostly elementary school-level) and data-gathering (marine biology)	WWF

Table 15: The list of identified running Education projects according to the typology offered by Wiggins and Crowston (2011)

Appendix 4: CS-related attitudes

These tables reflect the attitudes towards CS as measured by questions 11-15. A 6-step Likert scale was used for all questions. 1 represents to "strongly disagree" while 5 represents "strongly agree". "Undecided" respondents are left out of these tables.

Variable and sub-question, question 11	**Obs**	**Mean**	**SD**	**Notes**
p1 Particicants in CS projects receives a learning gain	141	4.141844	.7519647	Scored significant-ly lower by science institution-affiliated PIICS
p2 CS projects facilitates edu-cation of the population	143	4.146853	.777845	
p3 CS project participation is mostly dependent on the personal interests of the citizen	142	4.246479	.7164394	
p4 CS project participants are able contributors to the pro-jects	119	3.798319	.7316088	
p5 Recruiting CS project par-ticipants is easy	103	3.135922	.8750187	Scored significant-ly higher by CS project volunteers

Variable and sub-question, question (12)	Obs	Mean	SD	Notes
d1 Data collected in CS projects is low quality	123	2.495935	.9266013	
d2 CS projects can collect valuable data	136	4.352941	.735647	Scored significantly higher by science institution-affiliated PIICS
d3 Data collected in CS projects is generally less reliable than data collected by conventional methods	120	3.016667	1.115086	Scored significantly lower by science institution-affiliated PIICS
d4 It is expensive to collect data through CS projects compared to traditional research projects	105	2.07619	.7683053	
d5 It is time-consuming to collect data through CS projects compared to traditional research projects	106	2.613208	1.04718	
d6 Data collected in CS projects is generally credible.	122	3.590164	.8003522	Scored significantly higher by science institution-affiliated PIICS

Variable and sub-question, question (13)	**Obs**	**Mean**	**SD**	**Notes**
o1 Most CS projects are dependent of the newest technology	112	2.776786	1.104535	
o2 It is easy to fundraise CS projects	61	2.770492	.9017288	
o3 Most Danish CS projects are well-developed	81	3.444444	.8062258	
o4 CS projects should always be directed by scientists	132	3.386364	1.088789	
o5 Participants in a CS project should be involved in all phases of the project	130	2.792308	1.001519	
o6 CS projects should always be coordinated by NGOs	125	2.296	.8426533	
o7 CS projects should always be coordinated by science institutions	132	3.060606	1.068334	

Variable and sub-question, question (14)	**Obs**	**Mean**	**SD**	**Notes**
i1 CS projects can have a large political impact	120	3.808333	.802264	
i2 CS projects can have a large scientific impact	129	4.139535	.6817279	
i3 CS projects can assist the solution of important societal issues	118	3.940678	.7429713	
i4 CS projects influence the political decision-makers	106	3.481132	.8191881	Scored significantly higher by public management-affiliated PIICS
i5 CS projects connect the scientific community with the rest of society	131	4.320611	.659454	Scored significantly higher by public management-affiliated PIICS
i6 CS projects represent a meaningful way to increase public interest in science	133	4.43609	.607446	

Variable and sub-question, question (15)	Obs	Mean	SD	Notes
s1 The scientific community is generally skeptical towards CS project-based research	76	2.986842	.9450703	
s2 It is difficult to get scientific articles published if they are based on CS projects	54	2.648148	.8721565	Scored significantly lower by CS project volunteers
s3 CS projects can be incorporated in all sciences	95	3.389474	1.064862	
s4 CS project-based research is second-tier research	114	1.991228	.8466029	
s5 Research based on CS projects is recognized	83	3.445783	.7691143	Scored significantly higher by NGO-affiliated PIICS
s6 CS-based research can more easily be funded than traditional research	52	2.846154	.9157578	
s7 CS projects can address important scientific questions	127	4.070866	.7365848	
s8 More research should be based on CS projects in the future.	119	3.462185	.8712928	