# The anatomy of citizen science projects in information systems

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Abstract

Citizen science is an emerging approach for conducting research in the field of information systems. It refers to the participation of individuals with various backgrounds in research projects. It is necessary to match research implementation closely with plans because the anatomy of a citizen science project is quite complex. The literature shows that managing a long-term citizen science project is an even more complex task. To obtain a coherent understanding of citizen science in the field of information systems, we conducted a systematic literature review on the topic for which we used all the major information systems journals and conference proceedings. We devised the episode framework which consists of four blocks: design of pillars, the episodes of CS implementation, adjustment of activities, and the post-implementation. The framework emphasizes the division of the project into separate episodes which are sequentially ordered but which we need to run in parallel because of the dynamic nature of a citizen science project when participants can join and leave at free will. Moreover, in some projects, participants can progress to different roles, which complicates project management further.

# 1. Introduction

Information systems (IS) scholars are increasingly using data from beyond organizational boundaries (Crall et al., 2013; Levy & Germonprez, 2017; Lukyanenko, Wiggins, et al., 2019; Wiggins & Crowston, 2011), such as user-generated content from Facebook, Twitter, and other social media platforms, for their research. Because data is produced by citizens, and quite often consumed by them as well, it is natural for researchers that use data to draw on citizens to contribute to data collection and collation, and even to help them understand the content of the data and turn it into knowledge (Ulahannan et al. 2020). While this phenomenon raises several legitimate issues regarding the accuracy, quality, verification, and validation of data, it is believed and has even been shown to some extent that an approach called citizen science (CS) can help scholars address the issues without jeopardizing research agendas (Jackson et al., 2020; Lukyanenko et al., 2017; Lukyanenko, Parsons, et al., 2019).

Citizen science refers to a process whereby individuals with various backgrounds participate in research projects. These participants, or citizen scientists, who may not have any professional training, are volunteers who take part in research activities in various phases of the CS project life cycle. They may participate in resource gathering, research question definition, various forms of data collation including categorization or transcription, data analysis, dissemination of results, and evaluation of the success of a project. Quite often CS can also serve as a vehicle to make citizens more scientifically literate, thereby contributing to life-long learning, which is highly valued in our modern society.

For these reasons, IS scholars have recently become increasingly interested in citizen science (Jackson et al., 2020; Levy & Germonprez, 2017; Lukyanenko, et al., 2014b; Lukyanenko, Wiggins, et al., 2019; Simperl et al., 2018; Wright et al., 2019). However, IS research on citizen science is still fragmented, leaving much room for a greater focus on CS in the IS field (Levy & Germonprez, 2017; Lukyanenko et al., 2017; Lukyanenko, Wiggins, et al., 2019).

To apply citizen science IS scholars need to understand the anatomy of CS: the concepts, the structures, and the processes. This motivated us to conduct a literature review on citizen science. We decided to focus only on IS research in order to offer research findings of CS which are straight accessible for IS scholars. Thus, our research questions were:

- What are the main concepts of CS in IS research?
- How can we establish and conduct a successful CS project in IS?

To answer the research questions, we conducted a systematic literature review. The sources used for the review are the basket of eight IS journals, 47 Special Interest Groups (SIGs) recommended journals by Association of Information Systems (AIS), and the proceedings of five major IS conferences.

As is evident, the successfulness of a CS project depends heavily on participation, and therefore, we devise a synthesized framework that captures the designing needs and the dynamic nature of a CS project when the focus is on sustaining the motivation and engagement of citizen scientists. The framework, which we call the Episode framework, consists of four blocks: design of pillars, the episodes of CS implementation, adjustment of activities, and the post-implementation. Design of pillars includes three plans of which two are dealing how to motivate and sustain participation during the project. The episodes of implementation emphasize how creation of a net of meaningful episodes to participate is central when conducting a CS project. We argue that besides the fragility of establishing a functional CS project the process of conducting the CS project is complex and may involve both parallel episodes and sequential episodes where the output of an episode may be used as an input for another episode.

Based on our synthesis of the literature, we devise a framework for conducting a CS project. The framework, which we call the Episode framework, captures the designing needs and the dynamic nature of a CS project when the focus is on citizen scientists. The main concern of successfulness of a CS project depends heavily on participation. The framework consists of four blocks: design of pillars, the episodes of CS implementation, adjustment of activities, and the post-implementation. In particular, we argue that the process of conducting a CS project is complex and may involve both parallel episodes and sequential episodes where the output of an episode may be used as an input of another episode.

The paper is organized as follows. The next section gives a brief background of CS in the context of IS research. Section 3 describes our methodology. Our findings are presented in Section 4, and Section 5 presents a discussion. The final section consists of concluding remarks.

## 2. Background

Among the IS community, citizen science is now considered part of a movement toward research that is societally impactful as it facilitates research that is carried out by both researchers and people in their everyday lives (Crall et al., 2013; Levy & Germonprez, 2017). Citizen science also offers a lens through which to examine various aspects of society, such as behaviour, technology, and the environment (Levy & Germonprez, 2017; Lukyanenko, Wiggins, et al., 2019). This has recently led to growing interest in CS among IS scholars (Levy & Germonprez, 2017; Lukyanenko et al., 2014a; Lukyanenko, Wiggins, et al., 2019). For example, in their discussion of the potential of CS in IS research, Levy and Germonprez (2017) focused on the origins of citizen involvement in science and presented three perspectives of contemporary CS: sociological, natural science, and public policy perspectives. In their view, CS is best viewed within the context of current research activities because it resembles participatory design in many ways. Scholars have also identified close relationships between CS and several other concepts, such as user-generated content, social media, crowdsourcing, and collective intelligence (Awal & Bharadwaj, 2019; Mosier & Smith, 1986).

These multiple views and categorizations of CS reflect the complexity to understand of CS (Halavais, 2013). As a result, several literature reviews on CS have been conducted (e.g., Conrad & Hilchey, 2011; Ebitu et al., 2021; Lukyanenko, Wiggins, et al., 2019). None of these reviews, however, focused on CS in the IS. Nevertheless, Lukyanenko et al. (2019) discussed information quality (IQ) research opportunities in CS. They used exact-match querying for the phrase "citizen science" indexed in Web of Science, IEEE eXplore, Scopus, and ACM Digital Library. Based on their findings the authors concluded that much of the research on CS is published in non-IS and non-IQ journals and CS is being actively pursued by scholars who are rarely familiar with IS. Consequently, there is evidently a need for a literature review that maps research into CS in IS in order to understand how the IS community uses CS in research and how CS has been discussed in the literature. We aimed to understand how IS scholars view CS and how they conduct research related to CS in both academic and practical contexts to make relevant societal contributions (Levy & Germonprez, 2017).

**3. Methods**

To fulfil our research aims, we conducted a systematic literature review in the IS field (Paré et al., 2015; Templier & Paré, 2018; Webster & Watson, 2002). To improve reliability and minimize biases, we followed several techniques used by other researchers (Paré et al., 2015; Templier & Paré, 2018; Webster & Watson, 2002). The review process consisted of two main steps: selecting studies and analysing data (Paré et al., 2016). The two steps are described in detail below.

### 3.1. Selecting studies – Step 1

This step involved performing a literature search, evaluating papers, and selecting papers to study. The process is outlined in Figure 1. First, we performed a literature search by searching for papers among the AIS basket of eight IS journals: *Management Information Systems Quarterly* (*MISQ*), *Information Systems Research* (*ISR*), the *European Journal of Information Systems* (*EJIS*), the *Information Systems Journal* (*ISJ*), the *Journal of the Association for Information Systems* (*JAIS*), the *Journal of Information Technology* (*JIT*), the *Journal of Management Information Systems* (*JMIS*), and the *Journal of Strategic Information Systems* (*JSIS*). We also included the SIG recommended journals in AIS in our study, of which there are 47 (see Appendix A). Finally, we included the proceedings of five main conferences: (ICIS), the European Conference on Information Systems (ECIS), the Pacific Asia Conference on Information Systems (PACIS), the Americas Conference on Information Systems (AMCIS), and the Hawaii International Conference on System Sciences (HICSS). Thus, our chosen publication outlets consisted of 60 major journals and conferences in the IS field and the selected databases are presented in Appendix A. We used the AIS electronic library (AIS eLibrary) and the websites or portals of the individual journals and conferences for our literature search. We focused on the title, abstract, or the body of papers in AIS eLibrary and on the websites or portals of journals and conferences. The date range for our searches was until the end of May 2021.

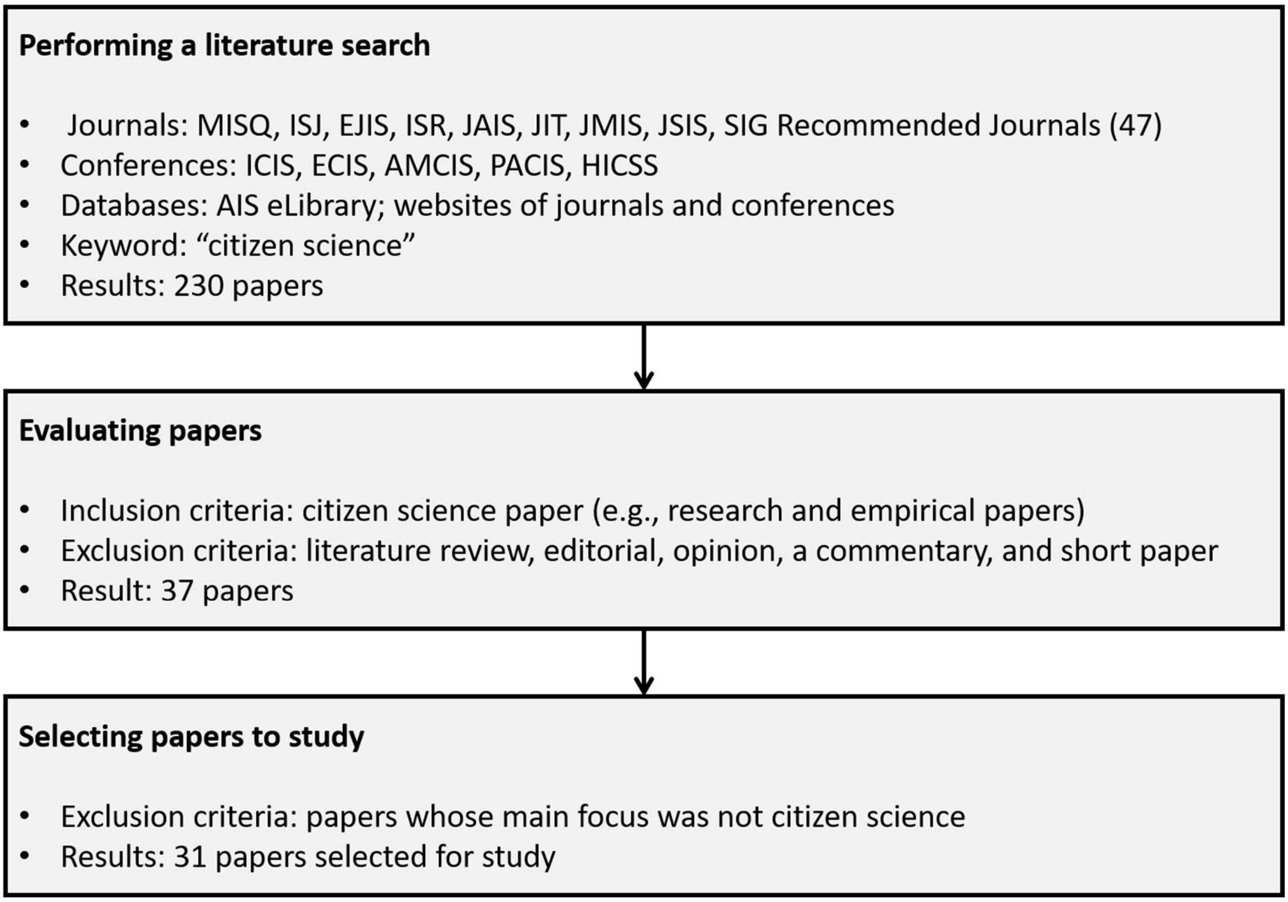


**Figure 1. Process of choosing the papers for study**

Second, we evaluated papers as follows. We used search engines and targeted research and empirical papers in the IS field that contained the term “citizen science” in the title, abstract, keywords, or the body of the paper. We eliminated literature reviews, editorials, opinions, commentaries, and short papers. This is because we are more interested in how citizen science projects are conducted, which often appears in research and empirical papers.

Third, we selected articles to study as follows. Each of us read and assessed papers based on their title, abstract, and keywords. If the title, abstract, and keywords did not provide enough information, we read through the body of the paper. Each of us assessed the papers independently; we then split into two pairs to read and assess each paper. During this process, we focused on whether the papers matched our research aims. We faced some challenges when deciding whether to include or eliminate papers, for example, few papers only used tools of CS for their own purposes without a connection to scientific research and therefore it was impossible to use them to answer our research questions. To address these challenges, we held several meetings to discuss and reassess the papers until a common opinion was reached. The selected papers are listed and numbered from 1 to 31 in Appendix B.

### 3.2. Analysing data – Step 2

We analysed the articles in three stages. First, we applied iterative coding process to all papers, analysed aspects relating to CS, and collected relevant evidence (Paré et al., 2015; Templier & Paré, 2018; Webster & Watson, 2002). The analysis was guided by a review framework, which consists of core ideas, terms, theoretical bases, and suggestions for future research (Table 1).

**Table 1. Review framework**

| Dimensions | Main questions |
|---|---|
| Core idea of the paper | What are the core research questions, scopes, and goals of the paper? |
| Concepts | How does the study view CS? What concepts, definitions, and characteristics are contained in the paper? |
| Method | What methodologies, including approaches, data collection and analysis, are used in the paper? |
| Theories | What theories do the authors use to substantiate their research? |
| Future research | What does limitations and suggestions for future research do the authors identify? |

In the second stage, our aim was to offer new insights into CS in the context of IS. Thus, we went beyond merely mapping or describing current discourses. We extracted core patterns from the data that emerged during the first stage. Specifically, we captured the main patterns and then identified relationships between those patterns. For example, all patterns related to concepts of CS and approaches to establishing a CS project were recorded or all patterns related to organizing of CS project were grouped. Next, we identified broader patterns from the previous steps. This involved grouping patterns into broader categories, which are presented in the findings section. Where necessary, we refined those patterns during the analysis process.

In the third stage, we analytically abstracted patterns around the activities of a CS project. We held lengthy discussions on the management process to devise ideas for a framework, such as blocks of activities and their contents. After several rounds of discussions and refinements, we identified four blocks: the design block, the episodes of CS implementation block, the post-implementation block, and the adjustment block. The content of each block came from selected papers (Appendix C). The episode framework is discussed in detail in Section 4.3.

## 4. Findings

In Section 4.1, we present the distribution of selected papers by year and by outlet. In Section 4.2, we collate our findings concerning different views of CS concepts and characteristics. In Section 4.3, we propose an episode framework for conducting and managing a CS project which includes various sequential and parallel steps.

### 4.1 Distribution of selected papers

Figure 2 shows the number of papers by outlets. Among journals, Computers in Human Behavior has published most CS papers (nine papers), and among conferences, Hawaii International Conference on System Sciences has published six CS papers and International Conference on Information Systems has published four papers.

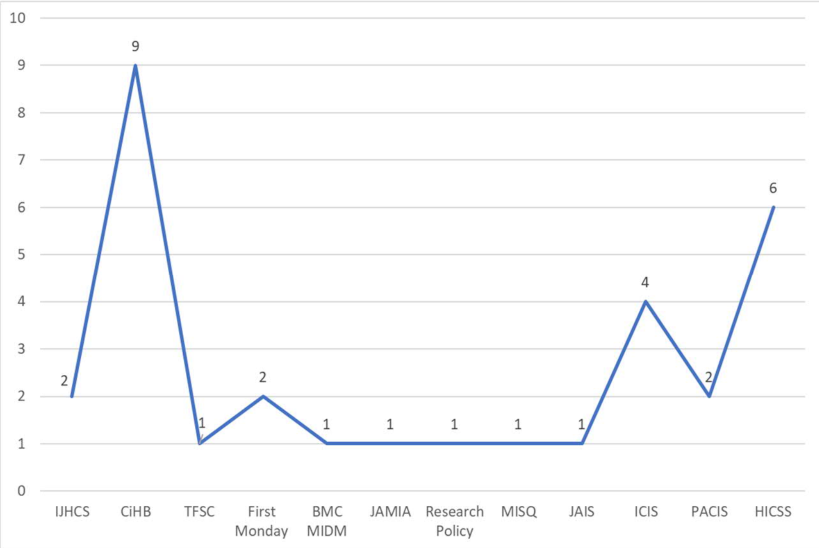


**Figure 2. The distribution of selected papers by outlets**

| | |
|---|---|
| IJHCS | International Journal of Human-Computer Studies |
| CiHB | Computers in Human Behavior |
| TFSC | Technological Forecasting and Social Change |
| First Monday | First Monday |
| BMC MIDM | BMC Medical Informatics and Decision Making |
| JAMIA | Journal of the American Medical Informatics Association |
| MISQ | Management Information Systems Quarterly |
| JAIS | Journal of the Association for Information Systems |
| ICIS | International Conference on Information Systems |
| PACIS | The Pacific Asia Conference on Information Systems |
| HICSS | Hawaii International Conference on System Sciences |

Although CS articles have been published in IS outlets since 2011, it seems that CS has gained momentum for the past five years as scholars have paid attention to CS topic since 2017 (Figure 3). This indicates that CS is still in the early stage in the field of IS.

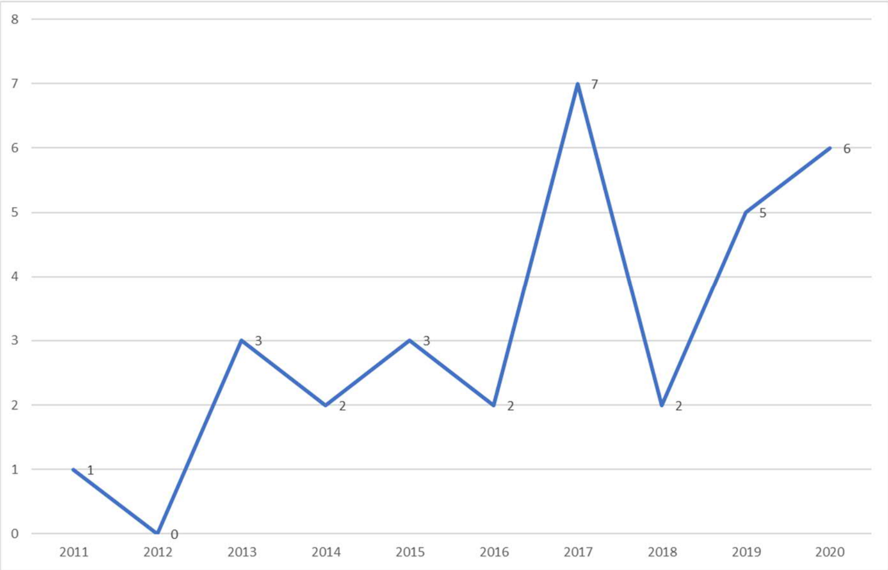


**Figure 3. The distribution of citizen science papers per year**

### 4.2. Concepts related to citizen science

In this section, we discuss the main concepts related to CS that emerged when we analysed the data from our selected papers. These include CS, CS participation, CS project, and other closely related concepts.

Citizen science is a relatively new aspect in IS. The definitions for citizen science in general as well in IS literature have variations (Halavais, 2013). We went through the definitions provided for CS in the selected papers and identified two characteristics. First, definitions have differences regarding the scope of participation in CS. For example, participants may take part in data collection and analysis (Huang et al., 2018), get involved in CS activities in their everyday lives (Levy & Germonprez, 2017), or even be involved in writing a scientific publication (Crowston et al., 2019). Second, although the definitions have differences (regarding the scope of participation), they refer to the participants in a similar manner. Participants are described as non-professionals, amateur participants (Sprinks et al., 2017), volunteers (Reed et al., 2013), public audience or citizens (Huang et al., 2018) who contribute data for scientific research and collaborate with professional scientists.

**Table 2 Example Definitions for Citizen Science**

| Citizen science | Reference |
|---|---|
| "involves members of the public (non-professional scientists) collaborating with professional scientists to conduct scientific research." | (Silva & Heaton, 2017) |
| "is a type of crowdsourcing in which scientists enlist ordinary people to generate data to be used in scientific research." | (Lukyanenko et al., 2014) |
| "is a form of social computation where members of the public are recruited to contribute to scientific investigations." | (Crowston & Prestopnik, 2013) |
| "is research [that relies] on the support of the general public to make progress." | (Harteveld et al., 2016) |
| "described as research conducted, in whole or in part, by amateur or nonprofessional participants often through crowdsourcing techniques." | (Sprinks et al., 2017) |
| "involves the general public in research activities that are conducted in collaboration with professional scientists." | (Cappa et al., 2018) |
| "refers to participation of volunteers in research projects led by professional scientists." | (Palermo et al., 2017) |
| "refers to partnerships between scientists and the public in scientific research in which data are collected and analyzed in response to a scientific or research-based question." | (Huang et al., 2018) |

Table 2 shows example definitions for CS extracted from selected papers. Based on our analysis of the definitions and their contexts in the literature, we identified common properties of CS and crafted a characterization of CS. It is centred on two properties: individuals (i.e., the persons who take part in CS) and scopes (i.e., the scope of individuals' participation in the project). Based on these two properties, CS can be characterized as a scientific process where the responsibility of scientific rigour is maintained by the organising scientists while main actions and duties can be carried out by volunteers with various backgrounds[1].

[1] It goes without saying that without citizen scientists we cannot run a CS project.

Based on the characteristics of CS, participation can include citizens' contributions to analysing (Cappa et al., 2018) or interpreting data or even to writing a scientific paper (Crowston et al., 2019) or collaborating in the management of a CS project (Huang et al., 2018). The characterization is also based on the assumption that a scientific research project involves the participation of scientists in the project. Activities involved in the scientific research project include the collection, categorization, transcription, and analysis of data. We stress that the individuals' activities are not limited to collecting or analysing data, which is implied in some definitions. Individuals that take part in a CS project may or may not be trained scientists. Citizen science participants are generally called citizen scientists.

In the literature, the term "citizen science project" is described in such a way it also provides supporting examples of the characteristics for the term "citizen science". The literature describes activities that are commonly part of CS projects. For example, Prestopnik et al., (2017) define CS projects as projects in which "members of the general public are recruited to contribute to scientific investigations." Moreover, CS research projects often use participants as sensors or data collectors but do not include them in data analysis or in the presentation of research results in the form of scientific reports (Sprinks et al., 2017). In addition, online or web-based platforms for data collection are often used for CS projects, which is similar to crowdsourcing (Crowston & Prestopnik, 2013; Sprinks et al., 2017; Tinati et al., 2017).

There are concepts, such as crowdsourcing and user-generated content, which are closely related to CS. For example, crowdsourcing specifically refers to a large group of volunteers external to an organization that perform distributed tasks or solve certain problems (Prestopnik & Tang, 2015; Schlagwein & Daneshgar, 2014; Zhou et al., 2017). Crowdsourcing provides organizations with access to free or low-cost labour for data gathering (Jackson et al., 2015). Therefore, it has been argued that crowdsourcing is similar to CS. However, the terms differ insofar as CS can be seen as one innovative type of crowdsourcing (Schlagwein & Daneshgar, 2014; Zhou et al., 2017), where people without any particular prerequisite or preliminary knowledge (Cappa et al., 2018) participate in scientific processes and generate data for scientific purposes (Lukyanenko et al., 2014). When it comes to the difference between crowdsourcing and citizen science, scholars have different views about that. For example, Levy and Germonprez (2017) argue that the difference between crowdsourcing and citizen science is that citizen science follows the structure of the scientific process and citizens can intervene in some or all stages of the scientific process, while (Wiggins & Crowston, 2014) view that the difference between citizen science and crowdsourcing is not clear as they have overlapping features (Wiggins & Crowston, 2014).

### 4.3. Episode framework for conducting citizen science projects

We synthesize the current practices involved in conducting a CS project from the selected papers into a framework called Episode Framework, which has episodes at the centre (Figure 4).The framework is intended to be used by IS scholar for designing, implementing, and conducting robust CS projects in information system research. The framework provides mechanism for ensuring that each vital aspect of CS project is considered. The framework consists of four blocks: design of pillars block, episodes of implementation block, adjustment block, and post-implementation block. The arrows in Figure 4 denote conceptual moves between blocks of the framework, which are taken when needed or when the current block ends. We describe the framework below with references. Appendix C provides the lists of references for each block.

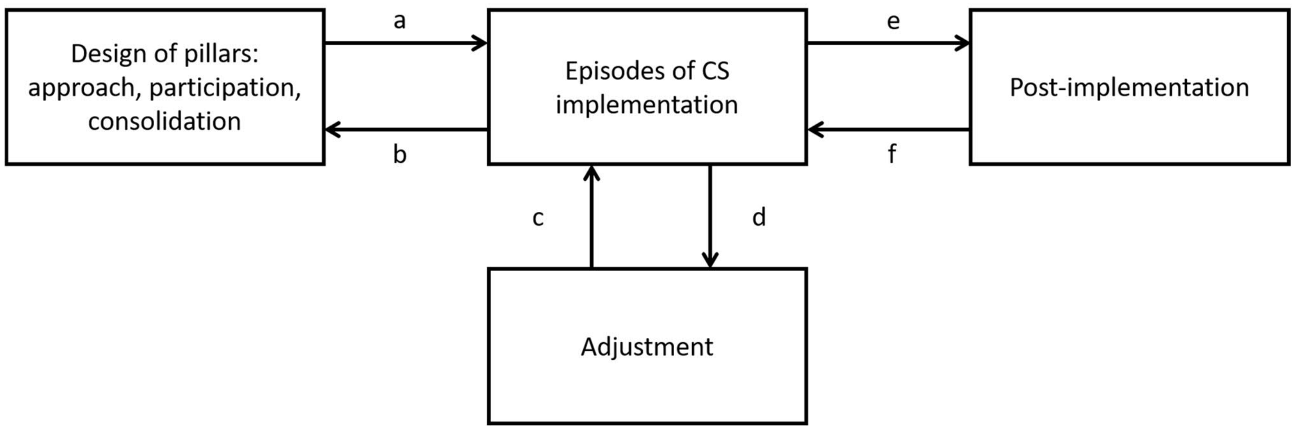


**Figure 4. Episode framework for conducting a citizen science project**

#### 4.3.1. Design of pillars

Although CS projects can have different elements and structural relationships (Halavais, 2013), many common features can be identified from the selected articles. Most of the features are concerned with the design of the project while the other features are connected to the management of a running project. As the features of the design were further analysed, three categories emerged, which we named approach, participation, and consolidation. The categories form the basic interconnected pillars on which a CS project can be built. We argue that considering all the three pillars as a design tool is enough for plans of a robust project, and at the same time all the pillars need to be considered to not leave out focal parts. The approach pillar includes plans for the general design of the project with structure and goals while the participation and consolidation pillars describe plans for how participants are supposed to be engaged and how the participation will be supported during the project. The list of pillars and their corresponding references are provided in Appendix C.

The first block in the framework is the design of a CS project as a whole before the project is actually implemented. The design can be carried out by using the approach, participation, and consolidation pillars, which all are described in the sections below.

**Approach pillar:** With this pillar researchers can identify the project's aims and type**,** and intended outcomes, and plans for implementation (c.f., Bonney et al., 2016; Turrini et al., 2018; Ulahannan et al. 2020).

The project's aims may include generating new knowledge, awareness-raising, facilitating in-depth learning, or enabling civic participation with enculturating volunteers in scientific practices and processes (Turrini et al., 2018; Huang et al., 2018). The goals and outcomes will depend on the project type and the mode of participation. The latter may involve contracts, contributions, collaboration, co-creation, or collegial working (Shirk et al., 2012). For example, in the case of a CS education project, the foundations and educational structure should be established in this pillar and should be considered in accordance with the primary goal of the project (Price & Lee, 2013).

With set-up goals for our project, we need to make the approach decision regarding the organisation and implementation of the project. Citizen science researchers have argued that the reality is often different from the promise when implementing a CS project. Different project types (e.g., data collection projects, data processing projects, and community projects) generate different challenges with respect to choosing an appropriate project design, identifying suitable criteria to measure and evaluate outcomes, and selecting methods to engage new audiences (Bonney et al., 2016; Crowston et al., 2019).

In terms of project type, citizen science projects can also take the form of learning labs set up by researchers. The labs enable participants to understand how hypotheses are formulated and how analyses are performed (Harteveld et al., 2016) as participants in CS projects may not have the skills necessary for hypothesis construction or results analysis. In a learning lab setting, even novices can learn how to create simple questionnaires and analyse the results in a relatively short period. Learning these skills may provide participants with opportunities to fully participate in a CS project from beginning to end (Harteveld et al., 2016). Moreover, the implementation can be categorized as a process-based approach and a learning-by-doing approach. In a process-based approach, researchers and participants strictly follow plans. By contrast, a learning-by-doing approach is more flexible and may be adapted to participants and to the goals of the project (Silva & Heaton, 2017; Lukyanenko et al., 2014b; Lukyanenko et al. 2019). For example, participants in a CS project that follows a learning-by-doing approach must develop and mobilize operational and digital skills, a process that depends on existing resources and competencies.

When the number of participants is high, as it is likely in a CS project, plans of implementation needs careful consideration because a situation may arise in which a participant submits a vast amount of data for evaluation. This challenge can be addressed using automated tools, for instance, an automated scoring system has been used to analyse sociolinguistic and other characteristics of submitted text, as well as the activities of participants (Nagar et al., 2016).

It is noted that there is no one-size-fits-all approach to designing and conducting a CS project (Holmer et al. 2015; Palermo et al. 2017; Prestopnik & Tang, 2015).

**Participation pillar:** With this pillar researchers can plan how to motivate and engage participants which form the foundation of participation, which in turn, forms the core of a CS project. The success of a CS project largely depends on its participants. In general, to support motivation and engagement, project management in general should be transparent by clearly communicating the project's goals, ethical viewpoints such as how data is used, who owns the data and who will benefit from results and how. (Beier et al., 2019; Sauermann et al., 2020).

According to Tinati et al. (2017) motivations can be grouped into four general classes: the desire to contribute, to learn, to be part of a community, and to be challenged, entertained and play. These all include usually both the intrinsic and the extrinsic motivations. The intrinsic ones relate to the act of contribution, user experience, and to support a worthy cause while extrinsic ones relate to behaviour, which is influenced by several factors, such as using their expertise for external rewards, or to reach an elevated status in the community through superior positioning on the leaderboard, and winning competitions.

In addition to motivational factors the user interface (UI) of online platform is a central tool for motivating new volunteers to contribute to CS projects (Jackson et al., 2015; Tinati et al., 2017). UI design and task workflow design make it possible to adjust the task to volunteers' level of expertise and enable them to satisfy intrinsic motivational factor such as engaging in purposeful activities together with the other contributors (Sprinks et al., 2017; Tinati et al., 2017). It can be also fruitful to allow experienced participants more autonomy in performing tasks (Sprinks et al., 2017).

In order to obtain data and ensure sustain participation researchers should focus on the engagement in a CS project. These include behavioural activities (e.g., sharing information, exploring data, and recruiting others), emotional factors (e.g., concern, commitment, and interest), cognitive activities (e.g., experiential learning, use of resources and skills), and social experiences (e.g., relationships, sharing resources and knowledge). These dimensions of engagement are largely influenced by motivational factors (Phillips et al., 2019; Reed et al., 2013). Thus, volunteer engagement is a particularly crucial element of a successful CS project and can be improved by task design (Prestopnik et al., 2017; Sprinks et al., 2017). The findings of our literature review show that the division of complex tasks into smaller, precisely defined tasks has a positive effect on volunteer engagement. Task design might also make volunteer engagement more sustained (Jackson et al., 2015; Sprinks et al., 2017; Tinati et al., 2017).

To strengthen volunteer engagement certain online platform features can be used (Zhou et al., 2017). Games, gamification, game elements such as using points and scoreboards are approaches that can be used to motivate and engage participants (Prestopnik et al., 2017; Tinati et al., 2017). If a game has an interesting story, the level of volunteer engagement may increase, and volunteers may contribute more to a CS project than they otherwise would (Harteveld et al., 2016; Prestopnik & Tang, 2015; Zhou et al., 2017). However, it should be considered that a game with a story ends at some point, which may lead to volunteers ceasing to contribute (Prestopnik & Tang, 2015). Moreover, rewarding volunteers monetarily or otherwise is effective mean of increasing and sustaining participation (Steger et al. 2017) but it may lead to a situation where the sole motivation for volunteer engagement is the reward (Cappa et al., 2018). Therefore, a CS project should offer different kind of roles and work with distinctive working mode, and communication mechanisms to motivate volunteers for sustained participation (Jackson et al., 2015; Jackson et al., 2016; Reed et al., 2013).

**Consolidation pillar:** The aim of the consolidation pillar is to provide the supporting mechanisms that further and secure the success of a CS project. Based on the selected literature, the mechanism should include at least the following: performance monitoring (e.g., task progress, data quality and volunteer collaboration), volunteer training and facilitation of collaboration between project personnel including scientists and volunteers.

Even at the highest level of a project, original plans may have to be changed. Therefore, constant monitoring based on traditional methods (surveys, interviews, etc.) or trace data is necessary, and this is usually very essential for a CS project because volunteers can come and go as they please (Crowston et al., 2020).

Data quality encompasses a multitude of dimensions, such as completeness, accuracy, consistency, validity, timeliness, currency, integrity, accessibility, precision, lineage, and representation (Jayawardene et al., 2015; Laranjeiro et al., 2015). Because data quality is one of the key areas in which challenges for achieving the goals arise during CS projects, constant monitoring is needed in most projects (Riesch & Potter, 2014). Some other examples of challenges include how to deal with datasets containing sensitive information or how to find a balance between transparency and privacy (Anhalt-Depies et al., 2019) or between open and closed standards (Pearce-Higgins et al., 2018).

Most CS projects require flexibility, which can be achieved through dynamic guidance and training for participants (Rosser & Wiggins et al., 2019). Since training affects data diversity, more trained participants produce more accurate data while less trained produce more diverse data, it should be aligned with the goals of the project (Ogunseye et al., 2020; Steger et al., 2017).

By choosing and resourcing a suitable volunteer training regime, it is possible to improve data quality and volunteer retainment (Beier et al., 2019; Jackson et al., 2020). Training needs to address all aspects of the project including even vocabulary which may introduce complications for newcomers (Jackson et al. 2019). In addition to training the vocabulary related issues can be solved by using common conceptual framework or model (c.f., Castellanos et al., 2020).

Moreover, participants or volunteers may lack the necessary skills to write a formal report or analyse data, in which case they should be given appropriate and specific instructions on how to carry out the steps of the project (Crowston et al., 2019). Finally, researchers should consider carefully choosing and clarifying user profiles, from novice to expert depending on the CS project's tasks and missions (Aristeidou et al., 2017).

Regardless of the approach adopted for a CS project, researchers should consider facilitation mechanisms for the collaboration and how to monitor progress (Aristeidou et al., 2017; Huang et al., 2018; Eames & Egmose, 2011). Good project design helps researchers to meet their goals, consider project risks in advance, and make adjustments if necessary. The selection of proper measurements helps to improve the success of a CS project as it has been argued that ensuring data quality and evaluating intended outcomes are the most challenging tasks associated with such a project (Crowston & Prestopnik, 2013; Dickinson & Bonney, 2012; Jordan et al., 2012).

**4.3.2 Episodes of CS implementation**

When the design of pillars block ends, the process moves to the episodes of CS implementation (Arrow a). In this block, one or more episodes may run sequentially or, in some cases, parallel, after which the control may revert to the design of pillars block (Arrow b) to revise the initial design if necessary.

Any CS project contains different phases—some of which are conceptually simple—such as data collection, while other phases such as synthesizing findings is more demanding (Eames & Egmose, 2011; Reed et al., 2013). In some projects, volunteers can be offered different roles and options to acquire skills for more advanced tasks related to project management. The observations imply that a CS project consists of several phases in the context of an individual and group level in addition to the project level (Crowston et al., 2019; Huang et al., 2018).

The CS project management, however, differs noticeably from a traditional project because volunteers can join and leave the project as they wish, and the CS project must provide its participants with a meaningful participation situation. Because of this, the steps of a traditional project are not suitable as such, we need to define a new concept called episode for a CS project. An episode provides meaningful context for the participants regardless of when participation takes place. The episode is therefore the perspective of each participant, which can be concurrent, differing and parallel. Therefore, we suggest that the implementation process should be divided into many different episodes, following one after another or in parallel as participants may join or leave at free will. The stakeholders involved in the project's planning may be limited to a small group of individuals with various backgrounds, but the episodes of CS implementation will involve all levels of participation and a wide range of tasks. The planned activities in each episode should include participant engagement maintaining (Jackson et al., 2015; Sprinks et al., 2017; Tinati et al., 2017) and motivation (Harteveld et al., 2016; Jackson et al., 2015; Prestopnik & Tang, 2015; Zhou et al., 2017).

#### 4.3.3 Adjustments

During each episode, feedback may be generated (Arrow c). The feedback may be used to guide any adjustments or refinements to the episodes (Arrow d). Examples of adjustment activities include assessing participant engagement, developing strategies to attract new audiences and participants, and strengthening the motivation, learning and performance of volunteers by using suitable feedback (Bonney et al., 2016; Zhou et al., 2020; Østerlund et al., 2020). Feedback (for volunteers already on the project for a long time) can consist of task performance or self-feedback about the progression of volunteer's competence and social feedback reflections of volunteer's competence compared with others (Zhou et al., 2020). The feedback itself can be implemented by interviews, questionnaires, personal or group observations, for example. If a CS project is conducted in a digital platform, then preferably conducting trace data gathering can be utilized (Østerlund et al., 2020).

Feedback provides the mechanisms that further and secure the success of a CS project. Based on the selected literature the mechanism should include at least the following to the adjustment: performance monitoring (e.g., task progress, data quality and volunteer collaboration), volunteer training and facilitation of collaboration between project personnel including scientists and volunteers. Even at the highest level of a project, original plans may have to be changed. Therefore, constant monitoring based on traditional methods (surveys, interviews etc.) or trace data is necessary, and this is usually very essential for a CS project because volunteers can come and go as they please (Østerlund et al. 2020).

### 4.3.4 Post-implementation

After several episodes, the process proceeds to the post-implementation block (Arrow e). In this block, researchers together with participants (depending on the project model) evaluate and measure the outcomes and analyse the impacts of the CS project (Crowston & Prestopnik, 2013; Dickinson & Bonney, 2012), report on the results, propose new directions for research, and share knowledge among volunteers (Jackson et al., 2015). For example, in this stage, researchers may measure the extent to which the project has generated new knowledge or created learning opportunities for participants (Turrini et al., 2018). Finally, the findings of the post-implementation phase can be used as inputs or references for further implementation episodes (Arrow f). A CS project often involves an iterative process rather than a linear one, and outputs of episodes are often used as inputs for other episodes.

## 5. Discussion

Citizen science is considered relatively new approach in IS research. As a result, there is no universal agreement on CS-related concepts or on terms closely related to citizen science, such as crowdsourcing, participation, and user-generated content, in the IS community (Jackson et al., 2015; Prestopnik & Tang, 2015; Zhou et al., 2017). Most scholars in the IS community have used CS as a tool. It has been used to improve data quality during the data collection phase of research projects and to improve the accuracy and completeness of data. For example, CS can be used to involve participants in the process of data collection in both the short and the long term. Lukyanenko et al., (2014) demonstrated that non-professional citizens with various backgrounds require fewer formal instructions and, thus, should be given more freedom in reporting observations.

Based on our synthesis of the literature, we devised a framework for conducting a CS project. Framework consists of four blocks: design of pillars, the episodes of CS implementation, adjustment of activities, and the post-implementation. The main character of our proposed framework are the episodes which tries to capture the view of the participants: how they can join and leave a project and still are expecting a meaningful process. We argue that the process of conducting a major CS project is complex and composed of a network of episodes occurring in sequential and parallel manner.

To conduct a CS project, researchers have devised several frameworks. Often presented frameworks are linear where the gathering of participants happens in the beginning and joining later is not supported. For example, (Eames & Egmose, 2011) proposed five phases for conducting a CS project: (i) engaging and recruiting participants, (ii) exploring narratives and perceptions of topics, (iii) sharing local knowledge and experience, (iv) envisioning sustainable communities, and (v) developing a community. Other frameworks utilizing digital platforms like Zooniverse (cf. Reed et al. 2013), are based on constant joining and leaving with a little support for specialisation of participants (Jackson et al. 2016). Thus, our framework can be seen as a purposeful synthesis where the project is designed so that the participants are at the centre. Because the episodes in our framework can occur sequentially or concurrently, different groups can participate in different episodes at the same time.

Each block of the episodes offers key factors that need to be addressed when designing a CS project. For example, a key factor regarding the approach to conducting a CS project in the design of pillars block includes organizing of CS project and planning to implement a CS project. CS project approach can be for example process-based approach, where plans are strictly followed, and a learning-by-doing approach, where plans are more flexible (Eames & Egmose, 2011; Reed et al., 2013). Regardless of which approach is taken, citizen scientists should consider issues related to citizen science project such as project design, performance monitoring,managing collaboration and participant involvement (Aristeidou et al., 2017; Huang et al., 2018; Eames & Egmose, 2011).

It has been stated that as CS projects usually deal with phenomena that interest both citizens and scientists, and therefore participant involvement in scientific processes increase scientific literacy and eventually leads to more informed citizens (Kullenberg & Kasperowski, 2016; Levy & Germonprez, 2017; Riesch & Potter, 2014) . We included the involvement of participants as a crucial factor to be considered in the design of pillars block. The involvement of participants affects the success of a CS research project largely which depends on participants (Jackson et al., 2015; Sprinks et al., 2017; Tinati et al., 2017). To attract new participants and improve and sustain participant engagement, researchers should consider three factors: participant motivation by task design, use of proper mechanisms and tools such as online platforms with gamified elements (Aristeidou et al., 2017; Cappa et al., 2018; Crowston et al., 2019; Prestopnik et al., 2017; Prestopnik & Tang, 2015; Schlagwein & Daneshgar, 2014; Sprinks et al., 2017; Tang & Prestopnik, 2017; Tinati et al., 2017; Zhou et al., 2017).

The proposed model acknowledges the fact that at some point of the project adjustment of activities might be needed. The adjustment aspect of CS project is addressed in the adjustment block. Adjustment activities can include for example designing feedback procedures as they provide support that can help in furthering and securing the success of a CS project. Furthermore, different types of feedback (e.g., motivational, reinforcement, and informational meanings) (Jaehnig & Miller, 2007) can be designed in accordance with participants' aims to inform them about their performance in tasks and activities (Curtis, 2014; Sullivan et al., 2014).

The measurement of participant performance, such as identifying the number of days of active participation (Boakes et al., 2016), the number of completed tasks or activities (Diner et al., 2018), the usefulness of the data contributed (Sprinks et al., 2017), or the total time spent participating each day (Boakes et al., 2016), should also be considered in the design of pillars. This includes the idea that researchers identify the challenges on how to evaluate outcomes (Jagacinski et al., 2001), how to deal with a lack of skills among participants, and how to improve data quality (e.g., in relation to sensitive information, transparency, and privacy) (Anhalt-Depies et al., 2019). Then, the planned measurements can be utilized in the adjustment block, and at the post-implementation block.

**Limitations**

This research has certain limitations. First, the searched databases are limited to the AIS basket of eight journals, 47 journals recommended by 15 SIGs, and the proceedings of five major IS conferences (ICIS, ECIS, HICSS, PACIS, and AMCIS). Papers outside these databases are not included in this research. This may have generated bias and only a partial understanding of CS. However, the majority of IS papers appear in our selected databases. Thus, we believe that our selection of journals and proceedings is appropriate.

Second, we searched for papers based on keywords. This may have eliminated some papers on CS, which do not contain our keywords. We managed this issue by having four researchers conduct searches independently within the selected databases. Third, the patterns presented in this research may contain biases introduced during the data analysis. We solved this issue by analysing the data from selected papers and carefully following established research methods (Paré et al., 2015; Templier & Paré, 2018; Webster & Watson, 2002). Moreover, each paper was analysed by at least two researchers based on the framework. We believe this significantly improves reliability and minimizes bias.

Fourth, we have yet to test the framework for conducting a CS project in practice. Future studies could focus on testing the framework or improving this proposal. Moreover, although the content of each block was retrieved from selected papers, researchers need to elaborate on those content by, for example, adding additional topics or revising, or replenishing the content of the blocks.

Finally, our data collection period ended at the end of May 2021, and articles accepted and published at the beginning of 2021 may not have been indexed by that point and were thus excluded. Moreover, only articles in English were analysed, so articles and the topics in other languages were ignored, which may have biased the results.

**Future research**

Our data shows that CS is less studied in the IS literature; a few articles with a direct focus on CS itself were found among the vast amount of first-class scientific resources consulted. A set of practical principles that can be used as a guide to conduct a CS project in IS may help scholars and practitioners to deploy such a project and achieve its aims in practice. There is also a lack of discussion on the relationship between scientists and members of the public (Shirk et al., 2012).

Therefore, we propose the following. First, future research should continue investigating practical guidance of CS projects in IS. Second, researchers should focus on issues related to CS project participants, such as the ideal set-up for a specific CS project, and the data collection methods that would best suit participants. Third, researchers should also focus on the interactions between scientists and members of the public participating in CS projects because communicating scientific processes solely by using scientific terms and concepts might be not easy to understand for citizens.

Even though the sciences, including the human sciences, have become more data-intensive, data collection and analysis cannot be fully automated. Citizen science has given researchers opportunities to use volunteers to gather, submit, and analyse large quantities of data. Thus, the scale of data collection activities is larger than it would be for a project involving scientists only (Bonney et al., 2016; Law et al., 2017). For most of the CS projects discussed in the selected papers, data is collected from participants in the public sphere (Huang et al., 2018), which may lead to issues related to verification and validation (Lukyanenko, Parsons, et al., 2019; Lukyanenko, Wiggins, et al., 2019). We suggest that future research should focus on addressing those challenges involving issues of verification and validation faced when gathering evidence and evaluating arguments. We emphasize that such research should focus particularly on non-professionals who take part in CS projects, where non-professionals are involved in the scientific processes of observing, taking notes, and collecting and collating data.

## 6. Conclusions

The aim of this research is to understand how citizen science has been studied and used by scholars. We also discussed about future research of CS in the field of IS. We conducted literature review based on the AIS basket of eight journals, 47 recommended journals of AIS SIGs, and the proceedings of five major IS conferences.

The research makes the following contributions. First, we clarify the concepts CS, CS project, CS participant, and other closely related terms, such as crowdsourcing and user-generated content, after which we propose a concise characterization of CS. Second, we presented an episode framework for conducting a CS research project.

The framework consists of four blocks: the *design of pillars* block, the *episodes of CS implementation* block, the *adjustment* block, and the *post-implementation* block (Figure 4). We argue that the process of conducting a CS project is not necessarily linear. We also discuss the important activities in each block, such as motivating and engaging the volunteers who take part in a CS project, and addressing challenges when conducting a CS project in the field of IS. In our proposed framework, the blocks and episodes may occur in parallel. The output of one episode may be used as the input of another episode. By using a parallel approach in our framework, we contribute to the literature as the steps of a CS project are often treated as linear in existing studies (c.f., Bonney et al., 2016).

This research also has implications for practitioners. CS projects differ depending on their aims and the environment and field in which they are conducted (Shirk et al., 2012). This may create confusion for researchers choosing an approach for conducting a CS project. We help researchers to address this issue by proposing an episode framework for conducting a CS project. Researchers can use the framework for reference when establishing a CS project. Each block of the framework has different topics, and those topics can be used as a starting point for researchers to study in-depth to clarify and contribute to CS projects. For example, researchers have to think about approaches in the design block, participation to achieve the aims of a CS project in the episodes block.

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**Appendix A. Selected SIG recommended journals**

| # | Journal | # | Journal |
|---|---|---|---|
| 1 | Academy of Management Journal | 25 | Information Technology and People |
| 2 | ACM Transactions on Computer-Human Interaction (ACM TOCHI) | 26 | Information Technology for Development |
| 3 | AIS Transactions on Human-Computer Interaction (AIS THCI) | 27 | Intelligent Systems in Accounting, Finance and Management |
| 4 | BMC Medical Informatics and Decision Making | 28 | International Journal of Human-Computer Studies (IJHCS) |
| 5 | Communications of Association for Information Systems | 29 | International Journal of Information Management |
| 6 | Communications of the ACM | 30 | International Journal of Information Security |
| 7 | Computers & Security | 31 | International Journal of Medical Informatics (IJMI) |
| 8 | Computers in Human Behavior (CHB) | 32 | Journal of American Medical Informatics Association (JAMIA) |
| 9 | Decision Sciences | 33 | Journal of Database Management |
| 10 | Decision Support Systems | 34 | Journal of Information Security |
| 11 | Digital Investigation | 35 | Journal of Information System Security (JISSec)+L13 |
| 12 | European Journal of Operational Research | 36 | Journal of Medical Internet Research (JMIR) |
| 13 | Expert Systems | 37 | Journal of Public Administration Research and Theory |
| 14 | Expert Systems with Applications | 38 | MISQ Executive |
| 15 | First Monday | 39 | Organization Science |
| 16 | Government Information Quarterly | 40 | Organizational Behavior and Human Decision Processes |
| 17 | Health Systems | 41 | Organizational Research Methods |
| 18 | Human-Computer Interaction (HCI) | 42 | Public Administration Review |
| 19 | IEEE Intelligent Systems | 43 | Requirements Engineering |
| 20 | IEEE Transactions on (Engineering) Management | 44 | Research Policy |
| 21 | IEEE Transactions on Software Engineering | 45 | Socio-Economic Planning Sciences |
| 22 | Information and Management | 46 | Technological Forecasting and Social Change |
| 23 | Information and Organisation | 47 | Telecommunications Policy |
| 24 | Information Systems Frontiers | | |

## Appendix B. Selected papers

| # | Selected papers |
|---|---|
| 1 | Sprinks, James, Jessica Wardlaw, Robert Houghton, Steven Bamford, and Jeremy Morley. "Task Workflow Design and Its Impact on Performance and Volunteers' Subjective Preference in Virtual Citizen Science." *International Journal of Human-Computer Studies* 104 (August 1, 2017): 50–63. |
| 2 | Holmer, Hrönn Brynjarsdóttir, Carl DiSalvo, Phoebe Sengers, and Thomas Lodato. "Constructing and Constraining Participation in Participatory Arts and HCI." *International Journal of Human-Computer Studies* 74 (February 1, 2015): 107–23. |
| 3 | Cappa, Francesco, Jeffrey Laut, Maurizio Porfiri, and Luca Giustiniano. "Bring Them Aboard: Rewarding Participation in Technology-Mediated Citizen Science Projects." *Computers in Human Behavior* 89 (December 1, 2018): 246–57. |
| 4 | Tinati, Ramine, Markus Luczak-Roesch, Elena Simperl, and Wendy Hall. "An Investigation of Player Motivations in Eyewire, a Gamified Citizen Science Project." *Computers in Human Behavior* 73 (August 1, 2017): 527–40. |
| 5 | Palermo, Eduardo, Jeffrey Laut, Oded Nov, Paolo Cappa, and Maurizio Porfiri. "Spatial Memory Training in a Citizen Science Context." *Computers in Human Behavior* 73 (August 1, 2017): 38–46. |
| 6 | Prestopnik, Nathan R., and Jian Tang. "Points, Stories, Worlds, and Diegesis: Comparing Player Experiences in Two Citizen Science Games." *Computers in Human Behavior* 52 (November 1, 2015): 492–506. |
| 7 | Aristeidou, Maria, Eileen Scanlon, and Mike Sharples. "Profiles of Engagement in Online Communities of Citizen Science Participation." *Computers in Human Behavior* 74 (September 1, 2017): 246–56. |
| 8 | Huang, Joey, Cindy E. Hmelo-Silver, Rebecca Jordan, Steven Gray, Troy Frensley, Greg Newman, and Marc J. Stern. "Scientific Discourse of Citizen Scientists: Models as a Boundary Object for Collaborative Problem Solving." *Computers in Human Behavior* 87 (October 1, 2018): 480–92. |
| 9 | Prestopnik, Nathan, (20) Kevin Crowston, and Jun Wang. "Gamers, Citizen Scientists, and Data: Exploring Participant Contributions in Two Games with a Purpose." *Computers in Human Behavior* 68 (March 1, 2017): 254–68. |
| 10 | Eames, Malcolm, and Jonas Egmose. "Community Foresight for Urban Sustainability: Insights from the Citizens Science for Sustainability (SuScit) Project." *Technological Forecasting and Social Change*, Backcasting for Sustainability, 78, no. 5 (June 1, 2011): 769–84. |
| 11 | Silva, Patricia Dias da, and Lorna Heaton. "Fostering Digital and Scientific Literacy: Learning through Practice." *First Monday* 22, no. 6 (June 1, 2017). |
| 12 | Halavais, Alexander. "Home Made Big Data? Challenges and Opportunities for Participatory Social Research." *First Monday* 18, no. 10 (October 1, 2013). |
| 13 | Lukyanenko, Roman, Jeffrey Parsons, and Yolanda Wiersma. "The Impact of Conceptual Modeling on Dataset Completeness: A Field Experiment," ICIS, 2014. |
| 14 | Nagar, Yiftach, Patrick de Boer, and A. C. B. Garcia. "Accelerating the Review of Complex Intellectual Artifacts in Crowdsourced Innovation Challenges," ICIS, 2016. |
| 15 | Zhou, Xinxue, Jian Tang, Tianmei Wang, and Yanlin Ma. "Investigating the Impacts of Task Characteristics in Gamified Citizen Science," PACIS, 2017, 13. |
| 16 | Schlagwein, Daniel, and Farhad Daneshgar. "User Requirements of a Crowdsourcing Platform for Researchers: Findings from a Series of Focus Groups," PAICS, 2014. |

| # | Selected papers |
|---|---|
| 17 | Crowston, K., and N. R. Prestopnik. “Motivation and Data Quality in a Citizen Science Game: A Design Science Evaluation.” In *2013 46th Hawaii International Conference on System Sciences*, 450–59, 2013. |
| 18 | Jackson, C. B., C. Østerlund, G. Mugar, K. D. Hassman, and K. Crowston. “Motivations for Sustained Participation in Crowdsourcing: Case Studies of Citizen Science on the Role of Talk.” In *2015 48th Hawaii International Conference on System Sciences*, 1624–34, 2015. |
| 19 | Reed, J., M. J. Raddick, A. Lardner, and K. Carney. “An Exploratory Factor Analysis of Motivations for Participating in Zooniverse, a Collection of Virtual Citizen Science Projects.” In *2013 46th Hawaii International Conference on System Sciences*, 610–19, 2013. |
| 20 | Crowston, Kevin, Erica Mitchell, and Carsten Østerlund. “Coordinating Advanced Crowd Work: Extending Citizen Science.” *Citizen Science: Theory and Practice* 4 (April 24, 2019). |
| 21 | Harteveld, C., A. Stahl, G. Smith, C. Talgar, and S. C. Sutherland. “Standing on the Shoulders of Citizens: Exploring Gameful Collaboration for Creating Social Experiments.” In *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 74–83, 2016. |
| 22 | Jackson, C., Østerlund, C., Crowston, K., Harandi, M., Allen, S., Bahaadini, S., Coughlin, S., Kalogera, V., Katsaggelos, A., Larson, S., Rohani, N., Smith, J., Trouille, L., & Zevin, M. (2020). Teaching citizen scientists to categorize glitches using machine learning guided training. *Computers in Human Behavior*, *105*, 106198. https://doi.org/10.1016/j.chb.2019.106198 |
| 23 | Zhou, X., Tang, J., Zhao, Y. (Chris), & Wang, T. (2020). Effects of feedback design and dispositional goal orientations on volunteer performance in citizen science projects. *Computers in Human Behavior*, *107*, 106266. https://doi.org/10.1016/j.chb.2020.106266 |
| 24 | Lukyanenko, R., Parsons, J., Wiersma, Y. F., and Maddah, M. 2019. “Expecting the Unexpected: Effects of Data Collection Design Choices on the Quality of Crowdsourced User-Generated Content,” *MIS Quarterly* (43:2), pp. 623–648. https://doi.org/10.25300/MISQ/2019/14439 |
| 25 | Østerlund, C., Crowston, K., and Jackson, C. 2020. “Building an Apparatus: Refractive, Reflective, and Diffractive Readings of Trace Data,” *Journal of the Association for Information Systems* (21:1). https://doi.org/10.17705/1jais.00590. |
| 26 | Beier, K., Schweda, M., and Schicktanz, S. 2019. “Taking Patient Involvement Seriously: A Critical Ethical Analysis of Participatory Approaches in Data-Intensive Medical Research,” *BMC Medical Informatics and Decision Making* (19:1), p. 90. https://doi.org/10.1186/s12911-019-0799-7 |
| 27 | Ulahannan, J. P., Narayanan, N., Thalhath, N., Prabhakaran, P., Chaliyeduth, S., Suresh, S. P., Mohammed, M., Rajeevan, E., Joseph, S., Balakrishnan, A., Uthaman, J., Karingamadathil, M., Thomas, S. T., Sureshkumar, U., Balan, S., Vellichirammal, N. N., and the Collective for Open Data Distribution-Keralam (CODD-K) consortium. 2020. “A Citizen Science Initiative for Open Data and Visualization of COVID-19 Outbreak in Kerala, India,” *Journal of the American Medical Informatics Association* (27:12), pp. 1913–1920. https://doi.org/10.1093/jamia/ocaa203. |
| 28 | Sauermann, H., Vohland, K., Antoniou, V., Balázs, B., Göbel, C., Karatzas, K., Mooney, P., Perelló, J., Ponti, M., Samson, R., and Winter, S. 2020. “Citizen Science and Sustainability Transitions,” *Research Policy* (49:5), p. 103978. (https://doi.org/10.1016/j.respol.2020.103978. |
| 29 | Jackson, C., Østerlund, C., Harandi, M., Kharwar, D., and Crowston, K. 2019. “Linguistic Changes in Online Citizen Science: A Structurational Perspective,” *ICIS 2019 Proceedings*. https://aisel.aisnet.org/icis2019/crowds_social/crowds_social/28. |

| # | Selected papers |
|---|---|
| 30 | Ogunseye, S., Parsons, J., and Lukyanenko, R. 2020. "To Train or Not to Train? How Training Affects the Diversity of Crowdsourced Data," *ICIS 2020 Proceedings*. https://aisel.aisnet.org/icis2020/sharing_economy/sharing_economy/9 |
| 31 | Rosser, H., and Wiggins, A. 2019. *Crowds and Camera Traps: Genres in Online Citizen Science Projects*, January 8. https://doi.org/10.24251/HICSS.2019.637 |

**Appendix C: Episode Framework and main content**

| Block | Reference |
|---|---|
| Design of pillars | **Approach:** Eames & Egmose, 2011; Harteveld et al., 2016; Holmer et al., 2015; Lukyanenko, 2014b; Lukyanenko, 2019; Bonney et al., 2016; Ulahannan et al. 2020; Price & Lee, 2013; Shirk et al., 2012; Palermo et al. 2017; Prestopnik & Tang, 2015; Reed et al., 2013; Silva & Heaton, 2017; Turrini et al., 2018<br>**Participation:** Beier et al., 2019; Cappa et al., 2018; Harteveld et al., 2016; Jackson et al. 2015; Phillips et al. 2019; Prestopnik & Tang, 2015; Prestopnik et al., 2017; Reed et al. 2013; Sauermann et al., 2020; Sprinks et al. 2017; Tinati et al., 2017; Zhou et al., 2017<br>**Consolidation:** Anhalt-Depies et al., 2019 ;Aristeidou et al., 2017; Beier et al., 2019; Bonney et al. 2016; Crowston & Prestopnik, 2013; Crowston et al. 2019; Dickinson & Bonney, 2012; Eames & Egmose, 2011; Huang et al., 2018; Jackson et al., 2019; Jackson et al., 2020; Jayawardene et al., 2015; Jordan et al., 2012; Laranjeiro et al., 2015; Nagar et al., 2016; Ogunseye et al. 2020; Pearce-Higgins et al., 2018; Riesch & Potter, 2014; Rosser & Wiggins, 2019; Steger et al. 2017; Østerlund et al. 2020 |
| Episodes of CS Implementation | Harteveld et al., 2016; Jackson et al., 2015; Prestopnik & Tang, 2015; Sprinks et al., 2017; Tinati et al., 2017; Zhou et al., 2017 |
| Adjustment activities | Aristeidou et al., 2017; Bonney et al., 2016; Crowston et al., 2019; Zhou et al., 2020; Østerlund et al., 2020 |
| Post-implementation | Crowston & Prestopnik, 2013; Dickinson & Bonney, 2012; Jackson et al., 2015; Turrini et al., 2018 |