Citizen science in information systems research: Evidence from a systematic literature review

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Abstract

Citizen science refers to partnerships between scientists and the public in scientific research. Citizen science is considered as an emerging approach for conducting research in the field of information systems (IS). However, there is a fragmented understanding of citizen science in the IS community. As a result, we conducted a systematic literature review on citizen science in IS field aiming at understanding what and how IS scholars view and conduct their research related to citizen science. We searched papers from the database of the basket of eight senior journals, 47 SIG recommended journals by the Association for Information Systems, and the proceedings of five major conferences in IS including ICIS, ECIS, HICSS, PACIS, and AMCIS. Our findings provide the current status of citizen science research in IS field, such as how scholars view about citizen science, how to set up a citizen science project, or how citizen science is adopted in IS community. This research also contributes to the field by laying out suggestions for the future research of citizen science.

1. Introduction

Information systems (IS) scholars are increasingly using data beyond organizational boundaries to conduct their research [14]. For example, data may include user-generated content from Facebook, Twitter, or other social media platforms. This phenomenon raises several legitimate issues, such as the accuracy, the quality, the verification, and the validation of data. Citizen science is considered as an approach that can help scholars dealing with those issues. Citizen science refers to partnerships between scientists and the public in their everyday lives in scientific research. With the public we mean participants who voluntarily take part in the research activities in various phases of the research life cycle. The participants can participate in resource gathering, research question defining, data collecting and analyzing, disseminating results and evaluating success of a project [20, 30, 37].

This leads to a growing interest in citizen science in IS scholars recently (e.g., [14, 16, 18]). Unfortunately, IS research on citizen science is fragmented and it seems overlooked. As a result, there is a call for research having the focus more on citizen science in IS field (c.f., [15, 17, 18]). This motives us to conduct a systematic literature review on citizen science research in IS field. Our aim is understanding how citizen science has been studied by scholars and lay out a research agenda for future research related to citizen science in the field of information systems.

Our research questions are: *What is citizen science and how do scholars use citizen science in information systems research?*

To answer these research questions, we conducted a systematic literature review. The review followed the guidance of [36], searching techniques, data analysis, and review process followed strictly the guidance of [22, 23, 34, 36]. Database sources are a senior basket of eight IS journals, 47 SIG recommended journals by AIS, and the proceedings of the ICIS, ECIS, PACIS, AMCIS, and HICSS conferences.

This research contributes to the literature by clarifying concepts including citizen science, citizen science project, citizen science participant, and closely terms to citizen science. We also provide insights into the process of implementation a citizen science project, such as approaches to conduct a citizen project, management of participants who take part in a citizen science project, challenges, and success factors when conducting a citizen science project in IS. Moreover, we lay out the research streams of citizen science in

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information systems. They include a stream on citizen science itself and a stream on how to adopt citizen science in information systems. Finally, we propose the initial steps to conduct a citizen science project.

The paper is organized as follows. Next are the background and methods sections, then paper continues with the findings section, following with the discussion section, and the paper ending with the conclusion section.

2. Background

Citizen science has now been considered as part of a movement towards societally impactful research in IS community [14], as this approach allows doing a research between researchers and people in their everyday lives. Moreover, citizen science provides lenses to look at different aspects of society, such as behaviour, technology, and environment [14, 18]. This leads to a growing interest in citizen science in IS scholars recently (e.g., [14, 16, 18]). For example, Levy and Germonprez [14] discussed the potential for citizen science in IS research, the authors focused on the origins of citizen involvement in science. They also discussed three perspectives of contemporary citizen science, including sociological, natural science, and public policy perspectives. In their view, citizen science is best viewed as situated among current research activities, such as it resemblances to participatory design. Similar vein, Lukyanenko et al., indicated that there are several concepts closely related to citizen science, such as user-generated content, social media, crowdsourcing, and collective intelligence [18].

So, there are different views on citizen science. This motives us to study how IS community using citizen science in their research and perspectives of citizen science that has been discussed in the literature. We aim at understanding what and how IS scholars view and conduct their research related to citizen science in both academically and practical ways and lay out a research agenda.

3. Methods

To fulfil our research aims, we conducted a systematic literature review [36]. To improve trustworthiness, minimize biases, and ensure reliability, we follow several techniques and guidance [23, 34, 36]. The review process includes two main steps: selecting studies and analyzing data [22]. The details of the two steps are described as follows:

3.1. Selecting studies

This step includes developing a review plan, searching the literature, and selecting papers for this study. First, we aim at research and empirical papers in IS fields that stated the term "citizen science" in the title, abstract, keywords, and/or the body of the paper. We eliminated literature reviews, editorials, opinions, commentaries, and short papers. Second, we searched papers by focusing on the AIS "basket of eight" IS journals. They include Management Information Systems Quarterly (MISQ), Information Systems Research (ISR), European Journal of Information Systems (EJIS), Information Systems Journal (ISJ), Journal of Association for Information Systems (JAIS), Journal of Information Technology (JIT), Journal of Management Information Systems (JMIS), and Journal of Strategic Information Systems (JSIS). We also included SIG Recommended Journals in AIS in our study. There are 47 recommended journals in total (see Appendix 1). Furthermore, we also included the proceedings of four main conferences: International Conference on Information Systems (ICIS), European Conference on Information Systems (ECIS), Pacific Asia Conference on Information Systems (PACIS), Americas Conference on Information Systems (AMCIS), and Hawaii International Conference on System Sciences (HICSS). As a result, our chosen outlets contained 60 main journals and conferences in IS fields.

We used AIS Electronic Library (AIS e-Lib), and the Journals' or conferences' website or portal in our study process. We focused on "Title", "Abstract", and "Subject" for AIS e-Lib and the Journals' or conferences' website or portal.

The selected papers are listed in Appendix 2.

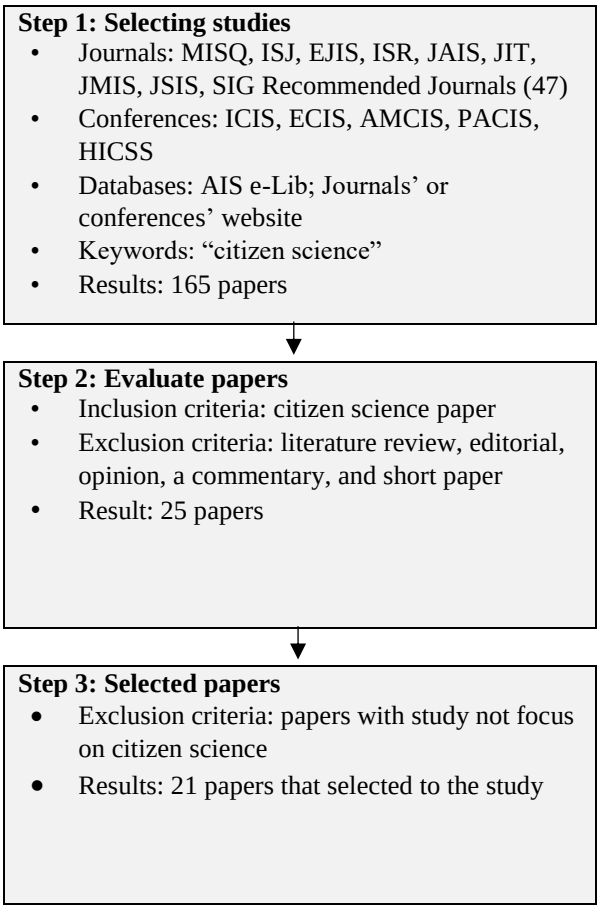

Figure 1. Process of choosing study's papers

Third, we select papers as follows: each member read and assessed papers based on their title, abstract, and keywords. We also read through the body of some papers if its title, abstract, and keywords could not provide enough information. Four authors read independently papers; we then divided into two pairs for reading and assessment at every paper. During this process, we paid attention to the papers that fit with our research aims. We also faced some challenges related to decision either elimination or not. In that case, we established a meeting to discuss and re-assess the papers. The process can be seen in Figure 1 and Appendix 1 lists the selected databases.

3.2. Analyzing data

Four authors then went through all papers with several iterative processes of coding. We analyzed aspects and collected evidence concerning citizen science [23, 34, 36]. The analysis was guided by the review framework (Table 1).

Table 1. Review framework

Dimensions	Main questions
Core idea of the paper	What is the core research question, scopes and goals of the paper?
Concepts	How does the study view citizen science, including author(s) means, definition, and characteristics?
Method	Methodologies and roles of theories, including approaches, data collection and analysis?
Theories	What theories have been used by the authors to substantiate their research?
Future research	What does author(s) suggestion for future research, as well as limitations?

The review framework was built on (a) core idea of the paper, (b) terms (if any), (c) theoretical bases of the papers, (d) the contributions and (e) the future research. We identified the main ideas that emerged during the coding process. For example, all contents related to the concepts of citizen science were coded and recorded. We refined the codes if necessary. At the final stage, we grouped codes into broader categories, which are presented in the findings section.

4. Findings

4.1. Concepts related to citizen science

We discuss the four main concepts related to citizen science that emerged when we analyzed data from our chosen papers, including citizen science, citizen science project, citizen science participation, and closely related terms to the citizen science.

First, there is no universal agreement on citizen science in the IS field. For example, it can be understood as "participation of volunteers in research projects led by professional scientists." [17:39]. Citizen science can also refer 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" [8: 481]. This can be explained by the fact that citizen science is still a new approach for the IS community. Although definitions vary, they have several similarities. For example, citizen science is known as public participation in scientific research where nonprofessional, amateur participants [32], volunteers [27], public audience or citizens [8] are

contributing data for scientific research and collaborate with the professional scientists.

Second, similar to citizen science, the term "citizen science project" is ambiguous. However, literature described common activities in citizen science projects. For example, [25] indicated that "members of the general public are recruited to contribute to scientific investigations" in citizen science projects. Moreover, citizen science research projects often use participants to act as a sensor or data collector excluding them to analyze research data or to present research results as a scientific report [32]. In addition, citizen science projects often utilize online or web-based [5, 32, 35] platforms for data collection similar to crowdsourcing.

Third, citizen science participant or citizen scientist is a term to indicate individuals who participate in a citizen science project. Participation can include citizens' contribution in analyzing [3] or interpreting data and even involve citizens in writing a scientific publication [4] or collaborate in project management in a citizen science project [8].

Finally, there are closely related terms to citizen science, such as crowdsourcing, participation, and user-generated content. In particular, crowdsourcing indicates a large group of outsourced volunteers that do distributed work, tasks, or solving certain problems [26, 38]. Crowdsourcing gives organizations access to free or low-cost labour for data gathering [9]. For those reasons, it is argued that "crowdsourcing" is similar to citizen science. However, the two terms differ, that is, citizen science can be seen as one innovative type of crowdsourcing [38], where people without any particular prerequisite or preliminary knowledge [3] participate in scientific process and generate data for scientific purposes [16]. Unlike in crowdsourcing, in citizen science project citizens intervene the whole scientific process (c.f. [14]).

4.2. Features of a citizen science project

We discuss the process of implementation of a citizen science project presented in the selected papers. We focus on the four main features. They include approaches to conduct a citizen project, participants who take part in a citizen science project, challenges, and success factors when conducting a citizen science project in the information systems field.

First, there is no one-size-fit-all approach to conduct a citizen project. For example, Eames and Egmose [6] conducted a citizen science project with five phases in the urban sustainability field including: (i) engaging local communities and recruiting participants, (ii) exploring narratives and perceptions of urban sustainability, (iii) sharing local knowledge and experience, (iv) visioning sustainable communities, and (v) developing a community-led agenda for urban sustainability research. Another example is that Reed et al., [27] deployed a citizen science project in Zooniverse with three main phases including: (i) use an online tool to recruit participants, (ii) conduct a survey to identify users motivation, and (iii) analyzing the data by the author. In this study authors also rewarded participants.

Furthermore, another approach for conducting a citizen science project is that researchers set up a learning lab during a citizen science project, where participants were able to understand how hypotheses were set up, formulated, and how the analysis was done (c.f., [7]). This is because, in many instances, a normal participant in citizen science project does not have skills for a hypothesis construction or results analysis. By using learning lab participants were truly able to absorb skills for setting up simple questionnaires and analyzing the results in relatively short time giving a promise that at some day participants could be fully participate in citizen science project from beginning to end (c.f., [7]).

Second, the number of participants who take part in a citizen science project is an important issue: it may affect the quality of the project and the data, and ultimately the project success. Unfortunately, literature does not state the ideal composition of participants for a citizen science project. For example, there are 199 ordinary participants in the Zooniverse for the VCS project [27]. While 28 researchers took part in project related to crowdsourcing platform development [29].

Third, regarding challenges when conducting a citizen science project, we may encounter a situation where a vast number of data submissions of participants should be evaluated. This challenge can be solved by using automated tools. For example, an automated scoring system has been used to analyze sociolinguistic and other characteristics of submission text, as well as activities of the crowd and the submission authors [19]. This approach can be adopted for other citizen science projects. Moreover, volunteers may lack skills for writing a formal report, and doing data analysis. In addition volunteers should be given quite suitable and specific instructions how to conduct steps of the project [4].

Fourth, there are several papers discussing about success factors when conducting a citizen science project. For instance, sustained volunteer engagement is one of the key elements in successful citizen science projects [32, 35]. The authors indicated that the division of complex tasks into smaller properly defined tasks has a positive effect on volunteer engagement of participants; it also enables the sustained volunteer engagement [9, 32, 35]. In addition, rewards (e.g., money or public online acknowledgement) are considered as a success factor in influencing and increasing volunteers' engagement level [3]. Motivation

is also an important factor to a successful citizen science project. For example, games are one approach to motive and engage participants or volunteers. If a game has an interesting story, volunteers' engagement level may likely increase, and they might contribute to a citizen science project more than they normally would [7, 26, 38]. Similar vein, Jackson et al., studied on sustained participants' motivations and balances of motivations during a citizen science project [9]. They concluded that any project, even short ones, should offer motivations' activities of participants, and therefore a citizen science project should offer different kinds of roles, works and communication mechanisms to attract longer participation. Silva et al., stated that knowledge exchange and learning new can be seen as a motivation to participate and engage in citizen science [31]. To sum up, maintaining volunteer engagement is an important factor in a citizen science project. It requires intrinsic and extrinsic factors such as a suitable platform, a sense of togetherness (e.g., community and sociality), meaningful tasks and common senses of purposes [1, 27, 38].

4.3. Citizen science in IS research

To understand how citizen science has been used in IS community we extracted main findings from the selected papers.

Majority of the selected papers in IS has used citizen science as an approach to improve data quality for a data collection phase in their research. This is because citizen science help to improve accuracy and completeness of data. For example, citizen science allows research design that attracts participants involving in the process of data collection both short and long terms. It is noted that non-professional citizens with various background require less formal instructions aka more freedom in reporting observations as was shown in [16]. Moreover, it is evidenced that the more users were forced to use a prior defined (professional) conceptual models, the less complete data they produced.

In citizen science projects, also gamification has been applied. It was shown that gamification can be used as a vehicle to sustain motivation and enhance data quality, literature also indicated that using citizen science approaches influence to a longer participation [5]. Moreover, volunteers who took part in a gamified tasks showed improved participation [25].

It is suggested that different user interfaces (UI) can be utilized in guiding volunteers while they take part in citizen science project. For example, when UI allowed participants to report what they were able to report (e.g., the system itself made some inference based on given attribute values to make more complete classification) the coverage were much complete and more new findings were made. Moreover, the quality of data that the volunteers provide will be affected by UI design and task design. For example, UI with strict steps and flows of the tasks could help to guide new volunteers, as well as aim at higher precision. On the other hand, UI with flexible steps and flows could use for experienced volunteers [32].

5. Discussion

5.1. Aspects of citizen science in information systems

From the findings section, we recognized that there are three aspects, including concepts, the process of implementation of citizen science project, and the use of citizen science in the IS.

First, citizen science is considered as a new approach in IS research. As a result, there are several definitions regarding citizen science, citizen science project, citizen science participant. However, they also have a lot in common. For example, all definitions of citizen science include nonprofessional, amateur participants [32], volunteers [27], generally public audience or citizens [8]. Moreover, citizen science projects vary when it comes to size, areas, and participants [5, 32, 35]. In addition, it is argued that there are several terms closely related to citizen science, such as crowdsourcing, participation, and user generated content [26, 38].

Second, the process of implementation of a citizen science project can be focused on the four main issues, ranging from *approaches* to conduct a citizen project, *participants* who take part in a citizen science project, *challenges*, and *success factors* when conducting a citizen science project in information systems field. It is noted that there is no common approach to conduct a citizen project. For example, it may have five phases (c.f., [6]), or it may have three stages (c.f., [27]), or even researchers can set up a learning lab to conduct a citizen science research (c.f., [7]). Moreover, the number of participants who take part in citizen science project is not clearly discussed in the literature. Participant number may range from a couple to thousands (c.f., [27, 29]). Challenges when conducting a citizen science project include data quality issues (researchers have to evaluate submitted data) [19] and scientific skills of volunteers [4]. Key success factors for conducting a citizen science project are: a sustained volunteer engagement [9, 32, 35], rewards (e.g., money or public online acknowledgement) [3], motivations [7, 26, 38], and maintaining the volunteer engagement [1, 27, 38].

Third, the use of citizen science in IS focuses on data quality and volunteer engagement. Data quality encompasses multitude of dimensions, such as

completeness, accuracy, consistency, validity, timeliness, currency, integrity, accessibility, precision, lineage and representation [10, 12]. Except one research, only accuracy has been in the focus of citizen science research in IS while there are equally important other dimensions as can be seen from the list. In particular, when non-professional people are working in a scientific process by observing, taking notes, collecting and collating data, it has to introduce practical problems along the project, which call for design decisions. Therefore, future IS research using citizen science needs resort to methods used in other fields for guaranteeing high data quality in other dimensions too [5].

Moreover, this research indicated that volunteer engagement is one of the key elements for a successful citizen science project. Volunteer engagement can be improved by proper task design, by utilizing online platforms with game elements, and by strengthening the motivational factors [25, 32]. Motivation is a factor to enhance engagement in citizen science, motivations, along with UI design invite and lure new volunteers to contribute to citizen science projects. It also can be used for inexperienced volunteers an opportunity to focus on certain simple tasks, and at the same time preserving the feeling that they are doing something with purpose together with the other contributors [32, 35]. In contrast, it could be fruitful to provide more autonomy on how to do the task for experienced participants. The increased level autonomy can be supported with UIs [32]. Furthermore, utilization of gamification and game elements (e.g., games with purpose [25]) in citizen science tasks is considered a good way for strengthening the volunteer engagement. Points, scoreboards and games with stories are one of the elements that can be used. However, for example, a game with story ends at some point that leads to a situation where volunteer might stop contributing [26]. Finally, although rewarding the volunteers is seen as an effective mean for creating and sustaining volunteers' engagement. Monetary or similar rewards may lead to a situation where the sole motivator of the volunteers' engagement are the rewards [3].

5.2 How to conduct a citizen science project

As discussed in the abovementioned sections, science has become more data-intensive, yet the data collection and analysis cannot be fully automated. Citizen science has given researchers an opportunity to utilize volunteers in gathering, submitting, or analyzing large quantities of data. Thus, the scale of data collecting activities becomes larger than it would be for scientists alone [2, 13].

As citizen science projects usually deal with a phenomenon that interests both citizens and scientists. We argue that participants' involvement in scientific process increases scientific literacy and eventually leads to more informed citizens [11, 14, 28]. As a result, in order to achieve a greater degree of public understanding of science, improving success, as well maximizing societal impacts, the citizen science project should consider and follow four main categories [2], they include:

- project design
- outcome measurement
- engagement of new audiences
- new directions for research

Furthermore, the following guidance of interaction models between scientists and members of the public should take into consideration when conducting a citizen science project [30]. They include:

- Contract: members of the public ask scientists to conduct a scientific investigation and report on results
- Contribute: members of the public are asked by scientists to collect and contribute data and/or samples
- Collaborate: members of the public assist scientists in developing a study and collecting and analyzing data for shared research goals
- Co-create: members of the public develop a study and work with input from scientists to address a question of interest or an issue of concern
- Colleagues: members of the public independently conduct research that advances knowledge in a scientific discipline

It is noted that there is not a single practical prerequisite for a CZ project in theory. However, the project needs a functional network and a suitable information system for aiding data collection in practice. Moreover, if project's design includes a higher levels of participation for citizens than just reporting observations for scientists, then the information system has to enable communication between participants and scientists.

5.3. Future research related citizen science in information systems

We proposed two streams of research related to citizen science in the information systems field, that is, research on citizen science itself and how to adopt citizen science in information systems.

First, as is evident from the data from selected papers, IS literature overlooked on research on citizen science itself. For example, how to set up a citizen science research from a beginning to an end. This is important. If we can propose principle guidance for conducting a citizen science project in IS, it helps scholars and practitioners easy to achieve and deploy the project aim in real-life practice. However, this task also challenging. Because of the variations of participants' background, cultural, and geography there is variation in data quality. Moreover, future IS should focus more on participants of citizen science issues, such as what size is appropriate, the advantages and disadvantages of different methods of collection of data to participants. Furthermore, studies using citizen science as an approach to develop citizen science platform for a citizen science projects are needed, as it helps to understand what a system should be like.

Second, adoption of citizen science in IS has been used mainly for improving data quality. As citizen science has a very wide range of scopes and goals, it can be used for educational outreach, community action, support for conservation, collecting data, and analyzing data for research purposes [25], even as an element of medical rehabilitation [21]. However, future research should continue studies how to ensure the quality of data that participants generate and how to get appropriate data for the citizen science goals of the projects. Furthermore, most citizen science projects in the selected papers collect data from the public sphere that participants involved [8], it may create the issues related to verification and validation. Future research thus should focus on taking those challenges to verify and validate research activities, such as gathering evidence and evaluating arguments.

Moreover, we are living in the digital age, leading to a growing interest in research using massive data, such as social media or big data. Citizen science fits very well for this purpose as it can be used for big data collection. As a result, future data collection for those researches should consider citizen science as an alternative approach to maximize the possible motivation of participating, as well as improve the quality of projects' outcomes.

In addition, it is evident from selected papers suggest that to get better results from a citizen science project, an efficient user interface has a crucial role. User interface with good usability and accessibility can support the engagement, motivation and data quality. For example, UI with gamification features improves participants' motivation to complete given tasks. Moreover, it affects positively to user engagement, as well as data quality. As a result, UI design should be have more research in the future, along with accessibility principles with different characteristics and capabilities [24].

6. Conclusion

This research aims at understanding how citizen science has been studied by scholars and layout research agenda for future research related to citizen science in the field of information systems. We conducted a literature review based on the basket of eight senior journals, 47 SIG recommended journals by AIS, and the proceedings of five major conferences in IS including ICIS, ECIS, HICSS, PACIS, and AMCIS.

The research has the following contributions. First, we present and clarify concepts related to citizen science, including citizen science, citizen science project, citizen science participant, and closely terms to citizen science. Second, we provide insights into the process of implementation a citizen science project, such as approaches to conduct a citizen project, supporting participants who take part in a citizen science project, and challenges with success factors when conducting a citizen science project in IS. For example, success factors include participant engagement, motivation, and rewards [1, 3, 4, 25, 26, 29, 32, 33, 35, 38]. Third, we identify the status of research related to citizen science, such as the majority of research papers focus on using citizen science as tools that assist researchers for doing their research, rather than research on issues of citizen science itself [7, 21, 27]. Finally, we suggest a future research agenda on citizen science, for example, research on individual engagement and community engagement has to be taken to consideration in the future [1, 32, 35]. Moreover, we also suggest that future research should focus on how to design and construct socio-technical artefacts that support citizen science process [5, 29], as well as investigations on how to support participant learning to increasing motivations for those who take part in a citizen science project [7, 8].

This research also has implications for practitioners by proposing the initial steps to conduct a citizen science project. In particular, we suggest that researchers should consider four categories, proposed by Bonney et al., when design a project a citizen science project (e.g., project design, outcome measurement, engagement of new participants, and new directions for research) [2]. We also suggest that citizen science researchers could consider five approaches, proposed by Shirk et al., when conducting a citizen science project. The approaches are contract, contribute, collaborate, co-create, and colleagues [30].

Limitations

This research has its limitations. First, the searched databases are the basket of eight senior journals, 47 SIG recommended journals by AIS, and the proceedings of five major conferences in IS including ICIS, ECIS, HICSS, PACIS, and AMCIS. Papers outside these databases are not included in this research. As a result, it may create some biases and partial understanding of a full picture of the citizen science. However, it is argued that the majority of the IS papers appear in our selected databases. We thus believe that our selection of journals and proceedings is appropriate. Second, we searched for papers based on keywords. This may eliminate some papers that study citizen science, but do not contain our keywords. We managed this issue by conducting the searching activities with four researchers independently on the selected databases. Third, patterns present in this research may contain biases during the data analysis. We solved this issue by analyzing the data from selected papers carefully following the research methods (c.f., [23, 34, 36]). Moreover, each paper has been analyzed by at least two researchers based on the framework. We believe this helps to improve significantly trustworthiness, minimizing biases, and ensuring reliability.

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Appendix 1. Selected databases from SIG recommended journals

#	**Journal**
1	Academy of Management Journal
2	ACM Transactions on Computer-Human Interaction (ACM TOCHI)
3	AIS Transactions on Human-Computer Interaction (AIS THCI)
4	BMC Medical Informatics and Decision Making
5	Communications of Association for Information Systems
6	Communications of the ACM
7	Computers & Security
8	Computers in Human Behavior (CHB)
9	Decision Sciences
10	Decision Support Systems
11	Digital Investigation
12	European Journal of Operational Research
13	Expert Systems
14	Expert Systems with Applications
15	First Monday
16	Government Information Quarterly
17	Health Systems

#	Journal
18	Human-Computer Interaction (HCI)
19	IEEE Intelligent Systems
20	IEEE Transactions on (Engineering) Management
21	IEEE Transactions on Software Engineering
22	Information and Management
23	Information and Organisation
24	Information Systems Frontiers
25	Information Technology and People
26	Information Technology for Development
27	Intelligent Systems in Accounting, Finance and Management
28	International Journal of Human-Computer Studies (IJHCS)
29	International Journal of Information Management
30	International Journal of Information Security
31	International Journal of Medical Informatics (IJMI)
32	Journal of American Medical Informatics Association (JAMIA)
33	Journal of Database Management
34	Journal of Information Security
35	Journal of Information System Security (JISSec)+L13
36	Journal of Medical Internet Research (JMIR)
37	Journal of Public Administration Research and Theory
38	MISQ Executive
39	Organization Science
40	Organizational Behavior and Human Decision Processes
41	Organizational Research Methods
42	Public Administration Review
43	Requirements Engineering
44	Research Policy
45	Socio-Economic Planning Sciences
46	Technological Forecasting and Social Change
47	Telecommunications Policy

Appendix 2. 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, 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," 2014.
14	Nagar, Yiftach, Patrick de Boer, and A. C. B. Garcia. "Accelerating the Review of Complex Intellectual Artifacts in Crowdsourced Innovation Challenges," 2016.
15	Zhou, Xinxue, Jian Tang, Tianmei Wang, and Yanlin Ma. "Investigating the Impacts of Task Characteristics in Gamified Citizen Science," 2017, 13.
16	Schlagwein, Daniel, and Farhad Daneshgar. "User Requirements of a Crowdsourcing Platform for

#	Selected papers
	Researchers: Findings From a Series of Focus Groups," 2014.
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.