Managing Citizen Science in the Humanities: The challenge of ensuring quality

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Montserrat Prats López

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To my parents.
Per als meus pares.

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Introduction

"All for one, one for all."
Alexandre Dumas (1802-1870)

Citizen science is a participative form of organizing and conducting scientific research, usually in the form of a project, where researchers and citizens work together to answer empirical questions (Cohn, 2008; Riesch & Potter, 2014; Wiggins & Crowston, 2011). In other words, citizen science involves professional and citizen scientists co-producing knowledge. Though citizen science projects can be initiated by public organizations, scientists or citizens (Wiggins & Crowston, 2011), the term 'citizen science' is usually associated with projects initiated by scientists who involve citizens in the collection and processing of data through the Internet (European Commission DG RTD and DG CNECT, 2014).

Citizen science is not a new phenomenon. The professionalization of science occurred in the 19th century (Olesko, 2008), and before then the people we now call 'scientists' were citizens with a wide range of professions (Silvertown, 2009). As such, citizens have been asked to help in solving organizational, societal and scientific problems for centuries. The idea behind citizen science is that, people can accomplish more by joining forces than alone. Our history is full of examples of people collaborating and combining their knowledge to solve scientific problems. A well-known example is the competition launched by the British Parliament in 1714 to find a way to determine longitude at sea (Afuah & Tucci, 2012; Jeppesen & Lakhani, 2010). The competition lasted for several years, was open to people of all nationalities and offered different prizes depending on the accuracy of the solutions contributed by participants (Johnson, 1989). The highest prize of £20,000 was awarded to John Harrison, a carpenter and clockmaker (Royal Museums Greenwich, 2015). Another example of a historical collaborative enterprise is the Oxford English Dictionary. In 1857, the Philological Society of London announced its intention to collect materials for a supplement to improve the dictionaries that existed at the time, and called for volunteers to read books and supply quotations to the editors (Gilliver, 2012). A year later, the editors decided to write a whole new dictionary and issued further open calls for volunteers.

Back then, participation in such projects involved volunteers writing and posting their paper-based contributions. Technological developments of the 20th century, and in particular the Internet, have opened up the range of possibilities for engaging a greater number of diverse people to come up with solutions to problems or to support collective endeavours. In 2014, about 78% of households in the European Union had Internet access through broadband (Eurostat, 2015). As the Internet and other technological artefacts have become cheaper and more accessible to both organizations and the wider public, the possibilities for distributed work have grown and new forms of organizing, such as citizen science, have emerged (Puranam, Alexy & Reitzig, 2014). Following on from the idea that larger groups of people can do more than one person or one organization on its own, an increasing number of individuals and institutions have taken advantage of the Internet to call for help in solving scientific problems. The Internet allows individual researchers or organizations to reach, coordinate and integrate the contributions of many people at a relatively low cost (Afuah & Tucci, 2012). New technologies are therefore an essential part of modern citizen science.

Though the ideas behind citizen science existed long before the Internet, it is because of such technological developments that the number of citizen science projects has grown in recent years (Wiggins & Crowston, 2015). The Internet is indeed increasingly used to support citizen science projects in different disciplines because it allows to reach a greater number of potential citizen participants. For instance, citizens participate in astronomy projects to understand the universe, by classifying images of galaxies (e.g.GalaxyZoo.org); they also contribute to the conservation of nature, by monitoring the number and distribution of birds (e.g. eBird.org); they support the advancement of medical research, by performing game-like activities to increase understanding of the structure of proteins (e.g. Fold.it); and make historical materials widely accessible and searchable, by transcribing handwritten letters and manuscripts of well-known people and making them available online (e.g. Transcribe Bentham). Yet, the increasing use of technology is a tendency of our society in general (Fiol & O'Connor, 2005) and not an attribute of any specific type of citizen science (Wiggins & Crowston, 2011), because all citizen science projects use technology and the Internet, albeit with different intensity and for different purposes.

The scientific problems that citizens are asked to help with are not only broad in terms of the types of topics, but also differ in the types of tasks: information gathering and processing, or ideation and experimentation (Boudreau & Lakhani, 2013; Brabham, 2013). The advantages of involving large numbers of citizens for ideation and experimentation-based projects lie in the access to a great diversity of knowledge that otherwise could not be reached; while the advantages for projects aimed at gathering and processing data are the time and resource efficiency with which these tasks can be achieved (Brabham, 2013; Franzoni & Sauermann, 2014; Shirk et al., 2012).

Research organizations can benefit from engaging in citizen science through the potential time and resource efficiency that results from involving large numbers of people to voluntarily collect, process or analyse information, perform a task or solve a problem (Brabham 2013; Franzoni & Sauermann, 2014). Moreover, the recent economic downturn has increased the pressure on public universities and research institutes to find diverse ways

to fund research projects (Estermann & Claeys-Kulik, 2013). The advantage of engaging in citizen science is that, in view of the limited resources of public research institutes, these projects allow them to perform empirical research that could not have been done without citizens contributing their time and knowledge to science (Riesch & Potter, 2014). Citizen science also allows a greater diversity of knowledge, the possibility of reaching individuals with specialized or rare knowledge, and the chance to detect errors, verify results and build upon each other's contributions (Franzoni & Sauermann, 2014; Jeppesen & Lakhani, 2010; Wexler, 2011).

Citizen science is also a means to improve the public understanding of science. Given the widespread access to information through the Internet, the general public is increasingly questioning the claims of scientific experts (European Commission, 2008). Educating the 'lay' public through unidirectional communication does not seem to be effective in improving public understanding of and engagement with science (European Commission, 2008; Haywood & Besley, 2014). Citizen science projects are not only initiated to support specific research questions, but often also include educating the public as one of their implicit or explicit objectives (Wiggins & Crowston, 2011).

1.1 The need for quality

Despite the importance and benefits of citizen science for researchers and society in general, the quality of citizen science outcomes remains a point of concern (Oomen & Aroyo, 2011; Riesch & Potter, 2014; Sheppard, Wiggins, & Terveen, 2014; Wiggins, Newman, Stevenson, & Crowston, 2011). This concern derives from the need for quality of information inherent to scientific research. High quality information is essential for science, because the reliability of theories and their application depends on the quality of data and their interpretation. Moreover, quality is of vital importance for research organizations to keep their long-developed expertise and trusted authority.

Empirical scientific research involves different activities, such as: choosing a topic; defining the research question; reviewing existing literature; developing hypotheses; designing the study; collecting, analysing and interpreting data; drawing conclusions and communicating results (Wiggins & Crowston, 2011). In the traditional research process, the quality of research outcomes is guaranteed by the rigorous training that researchers undergo (i.e. PhD or doctoral schooling), and by the established system of peer-reviews. Given the years of dedication that researchers spend on studying specific topics, it is obvious that there is a certain *knowledge divide* between academics and the general public (Miller, 2001).

In contrast, in the case of citizen science, it is a priori not clear what kind of knowledge and skills participants have, and it is also not possible to submit voluntary citizens to demanding and lengthy trainings. Specifically, the open and voluntary nature of participation in citizen science projects, means that there is no employment contract between the research organization and citizen contributors (Simula, 2013; Wexler, 2011). Citizens are free to decide whether and when to participate, which results in *participation and retention uncertainty*. There is no guarantee about the number of people who will enrol in a citizen

science project, the time they will make available and the effort they will put into performing a task. Moreover, the openness of citizen science also means that anyone can contribute to a project, bringing highly diverse knowledge and skills. Though this diversity is one of the benefits of citizen science, it also creates *knowledge uncertainty*. In conclusion, project leaders responsible for organizing a citizen science project do not know a priori who will participate (Franzoni & Sauermann, 2014), nor the type and level of knowledge they will bring to the project. Given these uncertainties, the concern about the quality of citizen science outcomes and the efforts to ensure it seem well justified.

If the outcomes of citizen science are to be valuable for scientific organizations, it is essential that the data resulting from such projects fulfil scientific quality standards. Concerns about quality in the scientific community could offset the benefits of citizen science and its acceptance as an effective means to organize the collection and analysis of data for research purposes (European Commission, 2015; Riesch & Potter, 2014). Quality is thus seen as a challenge and a priority among professional scientists who lead citizen science projects (Riesch & Potter, 2014). However, the literature on citizen science is diverse and scattered across disciplines, and it is not clear how scientists' need to obtain high-quality information affects the organization and working practices of citizen science (Preece, 2016). Therefore, in this dissertation I seek to answer the following research question:

How is the need for quality addressed in the organization of citizen science projects?

To answer this question, I examine how project leaders and citizens deal with the need to ensure the quality of citizen science project outcomes, and how technology is used for this purpose. First, I investigate how scientific quality requirements shape the organization of citizen science projects. Second, I look at the role of citizens and how project leaders' strive for quality affects the efforts and learning process of citizens. And finally, I examine the use of technology resulting from the need to standardize and integrate citizens' contributions in order to evaluate and ensure quality.

In the following pages, I first present the research approach taken in this dissertation, the research context, the cases of my empirical study and the research methods; then I introduce the three chapters that form the core of my research.

1.2 Research approach

The purpose of this dissertation is to gain a better understanding of the phenomenon of citizen science and to explain how the need for quality is addressed in citizen science projects. The most appropriate way to examine quality in the context of citizen science is to study projects as they happen in real life (Edmondson & McManus, 2007; Yin, 2011). To this end, I have taken a case study approach that has allowed me to consider the different perspectives of professional and citizen scientists as they engage in citizen science projects (Yin, 2011).

I have carried out an extensive qualitative multiple-case study concerning quality in the relatively new and complex phenomenon of citizen science, for which little theory exists (Edmondson & McManus, 2007). Studying multiple citizen science projects means that findings are more generalizable and better substantiated than with a single-case study (Eisenhardt & Graebner, 2007). Examining multiple projects has also allowed me to zoom into specific aspects of citizen science by selecting the cases in which these aspects are most apparent (Eisenhardt, 1989). In total, I have followed and compared five projects, giving equal attention to the social and material aspects that characterize their organizational practices (Leonardi, 2012).

1.2.1 Research context

Research on the phenomenon of citizen science has thus far mainly focused on projects in the natural sciences (Wiggins & Crowston, 2011), and less is known about public participation in other scientific disciplines. Given my interest in the humanities and the growing number of citizen science projects in this area, I have chosen to focus on five citizen science projects in the fields of history, language and literature. It is important to note that, in this dissertation, the terms scientist, scholar and researcher are used interchangeably, and that the word *science*[1] is used to refer to all fields of academic research.

Focusing on the quality of citizen science outcomes in the humanities is particularly interesting, because of the different criteria and means to justify knowledge compared with the natural sciences. While in the natural sciences knowledge is inferred from empirical observations, in the humanities knowledge is commonly more descriptive and symbolic in nature (Muis, Bendixen & Haerle, 2006). This has consequences for the way that knowledge is assessed and accepted. In the natural sciences, the consistency and reliability of information is important (Muis et al., 2006), which in citizen science can be achieved by comparing multiple observations of the same research object or phenomenon. This is how the quality of citizen contributions is ensured in projects such as Galaxy Zoo[2]. In contrast, the referent or reality written in historical or literary works lies in the past or future, and cannot be verified by experiments, observations and analysis of samples (Broudy, 1977). Therefore, in the humanities, knowledge is mainly evaluated in terms of textual and

[1] The word *science* comes from the Latin word *scientia*, which means knowledge or expertise, regardless of the field. Source: http://www.etymonline.com/index.php?allowed_in_frame=0&search=science

[2] https://www.galaxyzoo.org/#/story

historical accuracy (Donald, 1990) and authenticity (Broudy, 1977), which requires assessment by experts who look at the plausibility of data and findings (Muis et al., 2006).

As well as having different epistemologies, the academic fields also differ in their relationship to and use of technology. Compared to other disciplines, such as the natural and medical sciences, the impact of technological developments in the humanities has led to a shift in the traditional way of working (Arthur, 2009; Europeana, 2014; European Commission, 2014). This shift is characterized by a move from relatively solitary towards more collaborative research; by an increased use of online databases; and by changes in communication and information sharing with the public, from physical places to virtual spaces (Arthur, 2009).

The participation of the 'crowd' or citizens in the humanities and cultural heritage covers a wide range of activities, some of which are similar to the projects done in the natural sciences (e.g. tagging of pictures, such as the project "Tag! You're it!" organized by the Brooklyn Museum[3]). However, what makes the humanities particularly interesting is the involvement of citizens in performing knowledge-intensive tasks, such as the processing and interpretation of textual data.

Humanities research is mainly based on textual data, but only an average of 23% of the collections hold by European memory institutions had been digitized up to 2015 (Nauta & van den Heuvel, 2015). Therefore an increasing number of projects in this field are aimed at supporting the wider accessibility and searchability of literary and historical manuscripts by digitally transcribing them and making them available online to other researchers and the general public. Moreover, the practice of transcribing, editing and publishing literary and historical textual materials, also called 'scholarly editing', has always been an important part of the work of humanities researchers.

An essential aspect of scholarly editing is the accurate transcription of textual (handwritten) materials, following specific rules for both transcription and annotation or commenting of the texts. Scholarly editing has traditionally been done by experts within cultural heritage organizations (archives, libraries, museums) or humanities research institutes. In the past, these experts worked mainly autonomously, with feedback from peer experts, but basically they had the knowledge and made the decisions on what to work on (manuscript), how to work (process or method), and when and how to publish (Mathijsen, 2003). Opening-up the practice of 'scholarly editing', through citizen science, means first and foremost a change in the division of labour (Puranam et al., 2014). Transcriptions that were once performed by researchers or their assistants are now carried out by citizens via the Internet.

[3] https://www.brooklynmuseum.org/community/blogosphere/2008/08/01/tag-youre-it/

1.2.2 Case selection

Through existing contacts at the KIN research group, I approached three core organizations in the field of cultural heritage and humanities research in the Netherlands, namely: the Cultural Heritage Agency of the Netherlands, the Meertens Institute and the Huygens Institute for Netherlands History. By means of familiarization interviews with managers and employees of these organizations, I learned about several Dutch and international citizen science projects supporting research in the humanities and cultural heritage.

To select projects that would help address the research question, I used theoretical sampling (Eisenhardt, 1989). I selected projects involving knowledge-intensive tasks that required considerable theoretical knowledge and intellective skills (Hislop, 2008), such as the processing and interpretation of textual and historical data. Therefore projects merely aimed at tagging or classifying images were excluded. To generalize findings and uncover issues spanning across multiple cases, I selected five projects with maximum heterogeneity (Patton, 2002), except for one common property: they all required the transcription and/or translation of handwritten manuscripts of historical value.

The projects differed in terms of: the type of manuscripts (i.e. letters, notarial deeds, inventories, chronicles); the transcription conventions applied (i.e. "diplomatic", which means transcribing the text as it is, including deletions and mistakes, versus "normalized", where the text is adjusted to make it more readable); the technology used; the way the project was organized and the characteristics of the project leaders and citizens (i.e. type and number of participants, background, experience, level of proximity, employed vs. non-employed by the organization). A short description of the projects now follows.

The project 'Letters and Correspondents around 1900' started in 2009, with the objective of transcribing the letters from and to an important 19th century Dutch writer and making them available online. These transcriptions were intended for use by other humanities researchers. The scope of the project changed slightly over the years, as the correspondence of a contemporary 19th century artist was added to the project, resulting in a total of 5.512 letters of which 1.912 were transcribed during the project. Participants in this project were both volunteers with a literature background and literature students at a Dutch university. Together they constituted a small community of about 10 to 20 people. They used a web-based tool to integrate transcriptions. The scans and transcriptions have been available online since November 2016.

The project 'Digitizing Belle van Zuylen's Correspondence' started in 2010 and is still ongoing. The aim of the project is to digitize earlier paper transcriptions (published between 1979 and 1984) of the collection of private letters from and to this 18th century Dutch female writer. The participants' task involves adapting the 18th century spelling of these letters (mostly written in French) into modern-day language. Contributors to this project were, at the time of writing, members of an association interested in the work of this writer. They use e-mail as their means of communication and a web-based tool developed to integrate all contributions into one searchable online edition. They expect to make a first selection of the letters available online soon.

'Gouda on Paper' started in 2011 as a private volunteering initiative with the objective of publishing online transcriptions and translations of texts written before 1800, about or related to Gouda, which are kept in the regional archive. The first call for participants was made through local media. The project is still ongoing and more of the work is expected to become available online in 2016. Anyone can participate as long as they feel capable of performing the proposed tasks. The project has a relatively stable number of participants at about 50. They use various technologies to support their tasks: e-mail, Dropbox and a web-based tool to integrate transcriptions.

The 'Sailing Letters' project started in 2011 and took just over a year to transcribe about 5.800 scans from 17th-18th century handwritten documents. Participation was open to everyone who felt capable of carrying out this task. About 100 citizen volunteers contributed to the project. Communication took place through e-mail and an online discussion group. Individual contributions were integrated into one database through a web-based tool developed specifically for this project. The scans of the original documents and their transcriptions are available online to the general public.

'Transcribe Bentham' is a project of the University College London, which started in 2010 with the aim of transcribing the handwritten original work of Jeremy Bentham, a famous British philosopher and jurist who lived in the late 18th and early 19th centuries. Participation in this project is open to everyone. In the period of study (October 2012 to June 2014), about 3.000 people had registered; of these 400 had transcribed or partially transcribed at least one manuscript, and 11 were considered active contributors (i.e. had transcribed 100 folios or more). The project makes use of an online transcription environment (based on open source software) where all (diplomatic) contributions are posted and integrated.

1.2.3 Research methods

Focusing on citizen science projects means looking at the people who participate, the activities that take place in these projects and the technological artefacts that are used. A holistic approach of this kind is effective for theorizing about a new phenomenon like citizen science, and also for providing new insights for practitioners (Feldman & Orlikowski, 2011). By focusing on activities rather than practitioners (Nicolini, 2012), we can gain a better understanding of how the need for quality is addressed in such projects.

Data were collected in the period December 2012 to December 2015, through formal and informal interviews, observations, documents, images and quantitative data. Formal interviews followed a general interview guide and were conversational (Patton, 2002), allowing me to be flexible and adapt my questions to each person and specific conversation. This was particularly useful when interviewing volunteer citizens in their own homes. The interview guide started with an introduction, in which I asked about the background of the interviewees and how they came to be involved in the project. The interviews with professional scientists leading the projects, then included questions about setting up the project. All interviewees were asked about the activities that they and others performed in

the project, including questions about quality and the use of technology (see Appendices A and B). Interviews lasted for one hour on average, and were transcribed verbatim. I often asked interviewees, especially citizen volunteers, to demonstrate with examples how they usually performed a task. This enabled me to gain a better understanding of the task and to observe the setting in which they worked and how they interacted with the project's technological artefacts. In addition to formal recorded interviews, I also had informal conversations with project participants via telephone and Skype, of which notes were taken.

Table 1. 1. Overview of the cases

	Letters and Correspondents around 1900	**Digitizing Belle van Zuylen's Correspondence**	**Gouda on Paper**	**Sailing Letters**	**Transcribe Bentham**
Start of project	2009	2010	November 2011	November 2011	September 2010
No. of recruited (registered) citizens	20	7	60	100	3.000
No. of active* citizen participants	20	5	50	100	11
Type of documents	Letters	Letters	Books and Manuscripts	Letters	Manuscripts and letters
Scope (or size) of project**	1.912 letters	1.762 letters	1.000 pages	5.862 letters	15.634 pages
End of project	November 2016	Ongoing	Ongoing	October 2012	Ongoing

** Active citizen participants refers to people who have been engaged in the project for a longer period of time. This differs between projects.*

*** Scope refers to the number of letters or pages transcribed or translated in the project up to March 2016.*

I observed meetings, including work groups and technology training sessions. Though I mainly took an observer-as-participant role (Gold, 1958), I spent enough time in the field to develop a field relationship with some members and project leaders, allowing me to observe their activities more than once. While I did not participate in the project activities as such, I did have informal conversations with participants. During project meetings, I asked questions to clarify my understanding of what was being said, and in the training sessions, I observed how people performed their tasks, by walking around between all the participants, asking questions to get to know them and to understand the tasks and the issues they faced.

In addition to interviews and observations, I also collected several types of documents, including news articles, project newsletters, minutes of meetings, presentations, various versions of the project manuals, and an archive of e-mail messages from one of the projects. Moreover, given my focus on practices, I needed to bring technology's materiality into the analysis (Nicolini, 2012, p.4). For that purpose, I was granted access to two of the online platforms used in four of these projects. This allowed me to examine the features of technology, compare them between projects, and complement interviewees' statements and descriptions concerning these technological artefacts. I therefore retrieved images from documents and took screenshots of these platforms.

Finally, I received quantitative data from the *Transcribe Bentham* project, collected in the period from 1st October 2012 to 27th June 2014 by its project leaders. This quantitative data comprised details from 4.303 pages of submitted transcriptions that had been checked and approved by *Transcribe Bentham* staff. For each transcribed page, I used data on the number of words, level of difficulty (readability) of the handwriting, number of alterations (changes) made by the project staff, and a code to identify individual transcribers (anonymized).

Table 1. 1. Data sources

Source	Letters and Correspondents around 1900	Digitizing Belle van Zuylen's Correspondence	Gouda on Paper	Sailing Letters	Transcribe Bentham	Other*	Total
Qualitative data:							
Interviews							
Informal	3	2	4	-	2	-	11
Formal (recorded)	6	5	3	6	7	8	35
Observations							
Without interview	-	5	13	-	-	-	18
With interview (recorded)	-	1	2	-	-	-	3
Documents							
Manual (versions)	5	5	12	6	3	4	35
Website / blog (incl. project news)	1	5	4	1	2	3	16
Other documents	2	1	12	4	2	-	21
News articles (incl. open call)	-	1	4	2	1	-	8
Minutes from meetings	-	1	7	-	2	-	10
e-mail notifications	-	-	-	-	4.489	-	4.489
Technology documents							
Articles	-	-	-	-	-	1	1
Online sources	-	-	-	-	-	5	5
Images of technological artefact	5	5	9	-	2	9	30
Quantitative data:							
Submitted transcriptions	-	-	-	-	4.303	-	4.303

* **Other** refers to managers, project leaders and other professionals across the different organizations directly or indirectly related to these projects.

1.3 Dissertation outline

To understand how the need to ensure quality outcomes affects the organization and working practices of citizen science projects, I focus on the three interrelated elements that characterize this phenomenon: science, citizens and technology. Specifically, from a scientific perspective, the outcomes of citizen science need to fulfil the quality standards established by scientific organizations. These outcomes are the result of tasks performed by voluntary citizens who contribute their time, knowledge and skills to these projects. And it is through the integration of citizen contributions into web-based platforms that outcomes become open to the general public or to other scientists for further research. Hence, each of the following three chapters highlights one of these elements, while the last chapter integrates them and discusses implications for theory and practice.

In Chapter 2, I examine how project leaders' need to ensure quality shapes the working practices in citizen science projects. In particular, I look at the activities used by project leaders to ensure that project outcomes fulfil scientific quality standards. Though scholars recognize the benefits of efficiency, effectiveness, reach and engagement when citizens are involved in the research process (Brabham, 2013; Franzoni & Sauermann, 2014; Shirk et al., 2012), and admit that crowds include highly skilled individuals (Brabham, 2011), there is still a general concern in the academic community about the quality of outcomes from citizen science (Oomen & Aroyo, 2011; Riesch & Potter, 2014; Sheppard et al., 2014; Wiggins et al., 2011). To achieve the potential benefits of citizen science, project leaders need to deal with the challenge of ensuring scientific quality in a context of open participation and knowledge uncertainty. I therefore seek to understand what activities project leaders organize to ensure the quality of citizen science project outcomes.

I approach this question through a knowledge management lens, because citizen science involves knowledge work, where citizens use their knowledge and skills to contribute to the scientific research process (Cooper, Dickinson, Phillips & Bonney, 2007). While traditional research ensures quality through its own specific validation practices (Jaime, Gardoni, Mosca & Vinck, 2006), it is less clear how quality is ensured in citizen science projects. Citizen scientists are not bound to the research organisation with employment contracts, nor do they necessarily aim at advancing their academic reputation by conforming to strict quality criteria and validation processes. Given that quality is an essential indicator of performance in knowledge-intensive settings (Haas & Hansen, 2007), and that performance improvement is a key aspect of knowledge management (Pfeifer, Freudenberg & Hanel, 2001; Linderman, Schroeder, Zaheer, Liedtke & Choo, 2004), a knowledge management approach is likely to help in understanding how quality is ensured in citizen science.

In Chapter 3, I consider the role of citizens and how project leaders' strive for quality affects the efforts and learning process of citizens. Citizens are individuals who are external to research organizations but connected to them through their voluntary participation in citizen science projects. The learning process of citizens and improvement of their contributions are essential for ensuring that the outcomes of citizen science projects satisfy

scientific quality standards. Therefore, in Chapter 3, I focus on the learning process of citizen scientists and how it takes place in practice.

To answer this research question, I look at citizen science from an organizational learning perspective. I examine existing organizational learning literature and build upon the multi-level organizational learning framework proposed by Crossan, Lane & White (1999). First, I suggest the new concept of 'Extra-organizational learning', to refer to the learning process of individuals and groups that are not employed by the organization but whose tasks are essential for the delivery of a product or service. And second, I examine empirically how extra-organizational learning takes place in citizen science and what research organizations do to facilitate it. For this purpose, I zoom into one of the five studied cases where learning is most visible (Eisenhardt, 1989), namely the citizen or crowd science project *Transcribe Bentham*. To understand how extra-organizational learning takes place, I use a mix of quantitative and qualitative data. The quantitative data allow measurement and visualization of participation and quality over time. The qualitative data clarify quantitative findings and tells us about the activities supporting extra-organizational learning.

In Chapter 4, I examine the use of technology resulting from the need to standardize and integrate citizens' contributions in order to ensure quality. Web-based platforms facilitate citizen science because they make it possible to integrate contributions from distributed citizens. Integration involves the 'standardization of data definitions and structures' (Goodhue, Wybo & Kirsch, 1992, p. 294), which ensure data reliability and allows their aggregation, comparison and searchability for research purposes. The use of web-based technological artefacts can also bring efficiency gains, by hosting multiple projects that attract more citizen participants (Franzoni & Sauermann, 2014). The question is whether citizen science projects using the same web-based platform actually use it in the same way, and if that's not the case, we should understand why. Since it is generally accepted that individuals often use technology in ways other than intended, my aim is to understand why citizen science platforms are used differently than envisioned by their designers.

To understand why technology is used differently than intended, I zoom into one citizen science project that exemplifies this situation. To study this phenomenon, I use the theory of affordances (Hutchby, 2001) and propose an analytical framework based on affordances and activity theory. An affordance is a relational concept that refers to the potential action that can be accomplished by using technology (Majchrzak & Markus, 2013). I propose to understand the unintended use of technology by focusing on how affordances turn into actual actions.

The following three chapters can be read as independent papers. They were written together with co-authors, so I have kept the first-person plural 'we' to refer to all the authors.

Table 1. 2. Outline of the dissertation

Chapter	Purpose & research question	Related output	Co-authors
1. Introduction	The purpose of the Introduction is to explain the challenge of ensuring quality outcomes in citizen science, and to introduce the main research question: How is the need for quality addressed in the organization of citizen science projects?	Parts of the introduction have been used during presentations and in earlier versions of Chapter 2.	-
2. Quality in the making: Managing knowledge in citizen science projects	Chapter 2 aims to examine the activities organized by project leaders to ensure the quality of citizen science project outcomes. The question to be answered is: How do citizen science project leaders ensure the quality of project outcomes?	A previous version of this chapter was peer-reviewed and presented at: OLKC conference (2016); AOM Annual Meeting (2015); 3rd European Theory Development Workshop in OMT & Strategy (2014).	Maura Soekijad, Hans Berends & Marleen Huysman.
3. Extra-organizational learning: Learning beyond organizational boundaries	The purpose of Chapter 3 is to examine the learning process of citizen scientists and how it takes place in practice. This is addressed by focusing on the concept of 'extra-organizational learning'. The research question is: How does extra-organizational learning take place in practice?	A previous version of this chapter was peer-reviewed and presented at: OLKC conference (2015).	Hans Berends, Marleen Huysman, Maura Soekijad, Tim Causer, Melissa Terras & Kris Grint.
4. The dynamics of affordances: Using an online citizen science platform	Chapter 4 aims to investigate the technology used to ensure quality. Since technology is often used in unintended ways, this chapter addresses the following question: How does the distinction between designed, perceived and actualized affordances help to explain the use of technology in unintended ways?	-	Marleen Huysman, Hans Berends & Maura Soekijad.
5. Discussion and Conclusions	This chapter summarizes the findings, and answers the main research question.	-	-

1.4 Theoretical relevance

I seek to provide a greater understanding of the phenomenon of citizen science by tapping into theories and frameworks from the fields of knowledge management, organizational learning, and technology and organizing. Applying these theories and frameworks in this new context allows me to focus on concepts that have thus far been either overlooked or under-researched.

First, by taking a knowledge management perspective to quality assurance in citizen science, activities aimed at knowledge assessment or evaluation come to the fore. Accounts concerning knowledge evaluation are limited, and are scattered across the broad management literature (Rasmussen & Haggerty, 2008; Geiger & Schreyögg, 2009, 2012). Knowledge evaluation has been mentioned in conceptual papers (Brown & Duguid, 1998; Schreyögg & Geiger, 2007), in a few articles about knowledge creation (Giroux & Taylor, 2002; Robertson, Scarbrough & Swan, 2003) and in empirical papers about knowledge sharing or transfer (Haas & Hansen, 2007; Kane, Argote & Levine, 2005; Leinonen & Bluemink, 2008; Pérez-Nordtvedt, Kedia, Datta & Rasheed, 2008). In my research, the evaluation or assessment of knowledge emerges as an essential aspect of knowledge management and citizen science.

Second, in order to examine the role of citizens and how their learning process contributes to the quality of citizen science outcomes, I propose the new concept of 'extra-organizational learning'. Extra-organizational learning refers to the process by which individuals external to the organization learn and, by improving their performance, benefit the focal organization. Extra-organizational learning emerges as a process mirroring intra-organizational learning through knowledge exploitation (Crossan et al., 1999).

Third, I contribute to the literature of technology and organizing by focusing on affordances and how these turn into actual technology-mediated actions. Recent research calls for attention to the process and conditions of affordance actualization (Bygstad, Munkvold & Volkoff, 2016; Strong et al., 2014). I propose an analytical framework, based on affordances and activity theory, to explain affordance actualization and the use of technology in unintended ways.

1.5 Practical relevance

This dissertation is relevant for researchers interested in the organization of citizen science projects. The interest in citizen science gained momentum following the launch of GalaxyZoo in 2007. Since then, many more projects have been initiated in different scientific fields all over the world, see for example: scistarter, zooniverse, and iedereenwetenschapper. This growing interest (Bonney, Cooper & Ballard, 2016) led to the creation of the Citizen Science Association in 2012, followed by the development of the European and Australian associations, in 2013 and 2014 respectively, and the launch in 2016 of the peer-reviewed open access journal 'Citizen Science: Theory and Practice'. This journal and these associations are aimed at supporting the citizen science movement by facilitating knowledge

sharing and networking among project leaders (citizenscience.org, ecsa.citizen-science.net, csna.gaiaresources.com.au).

The research reported in this dissertation is also relevant for citizen science practitioners because it covers one of the most important challenges in this new field, namely: ensuring the quality of project outcomes (Bonney et al., 2016). My findings are particularly relevant for humanities researchers because, so far, the literature on citizen science has mainly focused on projects in the environmental and natural sciences (Bonney et al., 2016; Franzoni & Sauermann, 2014; Wiggins & Crowston, 2011). In recent years, the interest in citizen science has increased in other scientific fields, especially in the humanities and cultural heritage domains (Oomen & Aroyo, 2011). In this dissertation, I review and compare several citizen science projects in the humanities, focusing on the various activities aimed at ensuring the quality of project outcomes, the role of citizens in achieving quality, and the use of technology in these types of projects.

2

Quality in the making: Managing knowledge in citizen science projects

"Knowledge management may become such a natural part of how people organize work that it becomes invisible."
L. Prusak (2001)

Abstract

Information of high quality is essential for empirical scientific research. Involving citizens, whose knowledge is diverse and unknown beforehand, raises concerns about the quality of citizen science outcomes. The voluntary nature of such projects, and differences in knowledge between scientists and citizens, lead to a priori uncertainty about the knowledge and availability of citizen participants. We take a knowledge management perspective to investigate how project leaders deal with the knowledge-related challenge of ensuring the quality of citizen science outcomes. Knowledge management concepts and theories help to explain how and why project leaders combine specific activities to deal with this challenge. Overall, we show that the approach used to acquire knowledge seems to be fundamental for deciding what activities to combine to ensure quality. Other factors influencing the choices for organizing tasks and sharing knowledge include: the proximity of citizen participants; the available technology and the knowledge characteristics of the task. The choice of which knowledge assessment approach to use depends on the number of participants and whether project leaders know the citizens' level of expertise. This paper contributes to the field of citizen science by providing a holistic view of the process of quality assurance. It also contributes to knowledge management by studying knowledge management processes in a non-profit context, and highlighting the usually overlooked process of knowledge assessment.

2.1 Introduction

Technological developments of the last two decades have had a significant impact on the way that scientific or scholarly research is organized and performed. This dissertation focuses specifically on the participation of citizens in research-related activities, which is known as 'citizen science'. Citizen science involves citizens in performing tasks as part of scientific or scholarly research projects (Cohn, 2008; Riesch & Potter, 2014; Wiggins & Crowston, 2011).

Organizations asking citizens to help with solving organizational, scientific and societal problems is not a new phenomenon, and we find examples in the early 18th century (Afuah & Tucci, 2012; Jeppesen & Lakhani, 2010). However, the Internet has increased the possibilities for reaching a greater number and diversity of people, who may potentially have the interest, knowledge and time to support research organizations in performing specific tasks.

Citizen science projects are typically organized to support or provide input for scientific research, which is seen as the knowledge-creating process par excellence. The quality of citizen science project outcomes is essential for empirical scientific research, because the reliability of research depends on it. However, the years of dedication that researchers spend on studying specific topics leads to an obvious knowledge divide between academics and the general public (Miller, 2001), which raises concerns about the quality of citizens' contributions (Oomen & Aroyo, 2011; Riesch & Potter, 2014; Sheppard et al., 2014; Wiggins et al., 2011).

That is to say, while project leaders in citizen science are usually professional scholars working for a research organization, other project members are citizens who voluntarily contribute their time and knowledge to the project. These citizens are often geographically distributed, they are not employed by the research organization (Simula, 2013) and are thus not subject to management supervision (Sheppard et al., 2014), nor are they necessarily experts in the specific research field. This leads to uncertainty about the knowledge, skills and availability of these participants, because they are a priori unknown to the scientists leading a project (Franzoni & Sauermann, 2014), and they can freely decide when, how and for how long they participate. This results in a knowledge management challenge for the leaders of citizen science projects, namely that project leaders need to ensure the quality of project outcomes in a context of knowledge divide and knowledge uncertainty.

Solving this challenge is extremely important for researchers and research institutes engaged in citizen science, because concerns about quality influence the acceptance of citizen science projects' ability to provide valuable research outcomes (Riesch & Potter, 2014). So far, existing research has not yet sufficiently explored this challenge. Some studies have discussed different ways by which researchers influence the quality of citizens' contributions. However, these studies have primarily described and classified single activities (Bordogna, Carrara, Criscuolo, Pepe & Rampini, 2014; Hunter, Alabri & van Ingen, 2013; Riesch & Potter, 2014; Sheppard et al., 2014; Wiggins et al., 2011), without

explaining how multiple activities may work in concert to actually ensure the quality of citizen science outcomes.

The aim of this chapter is to understand how project leaders cope with the challenge of outsourcing a knowledge-intensive task to a priori unknown citizens, and at the same time guarantee the scientific quality of project outcomes. We therefore set out to answer the following research question:

How do citizen science project leaders ensure the quality of project outcomes?

To address this question, we need to understand the process through which project leaders influence 1) the quality of citizens' contributions, and 2) how these contributions are assessed and improved. Given the challenge resulting from the knowledge divide between professional and citizen scientists and the uncertainty of citizen participants' knowledge, we propose a knowledge management approach to investigate how project leaders ensure the quality of project outcomes.

We have found that quality-assuring activities, as described in previous citizen science research, are essentially knowledge management activities. Project leaders combine multiple knowledge management activities to reduce the possibility of errors that can arise in the course of a project. The type and combination of activities is influenced by the number of citizens participating in a project, their physical proximity, their knowledge diversity and level of expertise, and also by the knowledge characteristics of the task and the available technology.

This chapter is organized as follows. First, we review what the citizen science literature has said about ensuring the quality of project outcomes. We then introduce the essentials of knowledge management and explain why we believe it is the right perspective to address our research question. Next, we describe the research setting and the methods for our empirical research. Our findings are then presented in the form of detailed accounts of the activities performed to ensure quality in five citizen science projects. We conclude by discussing the implications of these findings for the fields of citizen science and knowledge management.

2.2 Theoretical background

In general, quality is defined as *"the standard or nature of something as measured against other things of a similar kind"* (OED Online, 2014). In Citizen science, the quality of data has been defined as *"fitness for its intended purpose"* (Sheppard et al., 2014) which differs per project. Citizen science literature has discussed several activities that project leaders implement to ensure, assess and improve the quality of citizen science outcomes. These activities are not mutually exclusive (Allahbakhsh et al., 2013) and project leaders are said to normally use more than one (Wiggins et al., 2011). However, existing work mainly describes and classifies single activities, and does not really explain what activities are commonly combined, under what circumstances and why.

It is important to consider how multiple activities work in concert to ensure quality. There is no single activity that can ensure the quality of citizen science outcomes on its own, because citizen science projects usually involve complex data, multiple participants, and tasks often performed in several phases. Consequently, there are many possible sources of errors and occasions when they can occur. Potential errors can come from: the complexity of tasks and their underlying data; the difficulty or ambiguity of rules and procedures for performing tasks; and project participants (Wiggins et al., 2011).

First, tasks need to be correctly described if a project is to engage citizens with the knowledge and motivation to deliver the desired quality (Allahbakhsh et al., 2013). However, complex tasks are more difficult to express than simple ones (Afuah & Tucci, 2012) and any mistakes or inaccuracies in their design and description can compromise the quality of citizens' contributions. Hence, task design and simplification is an essential activity in reducing the risk of errors and ensuring the quality of contributions (Allahbakhsh et al., 2013; Riesch & Potter, 2014), although simplification of complex tasks can also go wrong and lead to confusing objectives or unclear task descriptions (Afuah & Tucci, 2012). Therefore task design alone, as a quality-assuring activity, does not guarantee the quality of project outcomes.

Second, project rules and procedures are meant to manage the performance of tasks, and their difficulty or ambiguity can also lead to errors. Activities that have been suggested to avoid these types of errors and ensure quality are: training, supervision or workflow monitoring, and project plans (Allahbakhsh et al., 2013; Bordogna et al., 2014; Riesch & Potter, 2014; Wiggins et al., 2011). However, citizens are volunteers, not subject to contractual agreements and usually geographically distributed, which means they are free to follow or ignore any project plans and are difficult to supervise, while their training is expensive and difficult to scale. Relying only on these activities will therefore not guarantee the quality of citizen science outcomes.

Third, to avoid errors due to the participants, the citizen science literature suggests activities such as testing participants' skills before or during task performance (Wiggins et al., 2011), for example by comparing their contributions with those of an expert (e.g. Microscopy Masters). However, such activities raise questions about how to deal with participants whose contributions are of lower quality than the rest.

In addition to reducing the chance of errors, citizen science research also emphasizes the assessment of citizens' contributions after their submission. Suggested activities include validation of the consistency of contributions by comparing them with existing scientific literature or professional observations (Riesch & Potter, 2014). However, this assumes that some information about the object or topic of research already exists. Other activities mentioned to assess contributions are expert reviews (Wiggins et al., 2011) and citizen peer-reviews (Brumfield, 2012). However, expert reviews require time investments, and citizen peer-reviews raise questions about how to select citizen reviewers and ensure that they deliver the desired quality. Investing in the assessment of contributions therefore seems most

beneficial for the project when citizens' contributions have some level of quality and/or are expected to improve.

Finally, technology is also mentioned as an important factor in ensuring quality. Technology can be used to collect data (e.g. sensors, scans) and to check the quality of submitted contributions at the time of data entry. For instance, controlled vocabularies help to avoid spelling and syntax errors, and specific metadata structures or templates support the accuracy of data entry (Bordogna et al., 2014). Technology can also support the versioning and tracking of data changes, for example with wiki-based technologies (Sheppard et al., 2014), and it can automate the identification of data deviations or irregularities (Wiggins et al., 2011). However, quality depends on the correct performance and precision of such technological tools (Bordogna et al., 2014), and little has been said about the integration of technology into any of the activities mentioned above.

Citizen science literature is thus, as yet, limited to the single description and classification of the above-mentioned quality assurance activities. To understand how the quality of citizen science outcomes is ensured, we need to examine the types and combinations of activities that project leaders use for this purpose. Since citizen science projects are characterized by the knowledge-divide between professional and citizen scientists and the knowledge uncertainty of citizen participants, we propose a knowledge management perspective to examine the activities carried out by project leaders to ensure the quality of project outcomes.

A knowledge management perspective on quality assurance

Citizen science projects involve knowledge work. First, tasks, whether simplified or not, are derived from and contribute to the scientific research process (Cooper et al., 2007). Second, these tasks depend on human skills (Wiggins & Crowston, 2011) involving a certain level of creativity and resulting in unique outcomes (Hislop, 2008) to support specific research objectives. And third, the creation or development of such unique outcomes (or research products) entails the integration and application of knowledge (Hislop, 2013) of both professional researchers and citizen participants.

Therefore, quality assurance in the context of citizen science represents a knowledge management challenge. That is to say, on the one hand, science benefits from engaging citizens in performing specific knowledge-intensive tasks; but on the other hand, it needs to deal with citizens' unknown and generally inferior level of scientific knowledge (Franzoni & Sauermann, 2014; Miller, 2001). In addition, potential errors may come from the complexity of the tasks and underlying data, and also the rules and procedures used to manage citizen science projects (Wiggins et al., 2011). And the more complex the tasks, the more difficult it is to validate the quality of their outcomes (Hislop, 2013).

A knowledge management perspective provides the concepts for analysing quality-assuring activities in a context characterized by knowledge challenges. Knowledge management refers to the processes or sets of interconnected activities intended to acquire, share and apply knowledge within organizations in order to achieve organizational objectives, such as improving organizational efficiency and effectiveness (i.e. higher-quality

outcomes) (Alavi & Leidner, 2001; Dalkir, 2011; Hislop, 2009). The interconnectedness of knowledge processes is key here, because it shows that different activities need to work in concert to achieve organizational objectives, in our case 'high-quality outcomes'. Therefore, to understand how project leaders ensure high-quality outcomes in citizen science, we need to analyse the role of project activities in managing knowledge work and dealing with the challenge described above.

Knowledge acquisition refers to the set of activities used to obtain new knowledge for the organization. New knowledge can be acquired by learning (Huber, 1991) and/or by hiring new employees (Davenport & Prusak, 2000), that is, by acquiring knowledgeable human resources. In a research organization, new knowledge is acquired through research and learning activities, but also by selecting and hiring employees with distinct knowledge and expertise. In contrast, in a citizen science project, scientific project leaders do not select and hire employees. Instead, citizens voluntarily decide whether or not to participate in a project. This is often referred to as 'self-selection'. Examining the activities used by project leaders to recruit citizen participants, enables us to understand the role of these activities in the process of ensuring high-quality outcomes.

Knowledge sharing or transfer refers to communicative activities by which individuals make part of their knowledge available to others (Berends, 2005). Some communicative activities are more suitable for transferring explicit elements of knowledge (e.g. what protocols to follow), while others are better for sharing tacit aspects of knowledge (e.g. how to perform a test) (Alavi & Denford, 2011). Depending on the task outsourced to citizens, some knowledge sharing activities will be more suitable than others. By exploring knowledge sharing activities in citizen science, we can understand how project leaders deal with the knowledge divide and knowledge uncertainty, and ensure quality.

Knowledge application refers to the performance of a task or job by using specific knowledge and skills. In research organizations, tasks are allocated on the basis of employees' skills and expertise, while in citizen science, people themselves decide which tasks they want to perform (Puranam et al., 2014). Moreover, employees receive monetary rewards for applying their knowledge to achieve organizational objectives, while citizens are non-paid volunteers. Investigating how tasks are performed in citizen science, can help us understand how knowledge is applied to ensure quality.

2.3 Methods

2.3.1 Research setting

Citizen science in the humanities (e.g. history, literature) is a particularly interesting setting for this research because citizens contribute not only to data gathering but mainly to the more knowledge-intensive activities of interpretation and data processing. Moreover, new technologies and the ever larger sets of data made available through citizen science contribute to the further development of the field of digital humanities. Digital humanities refers to the new and interdisciplinary field where humanities research and new technologies

come together, making scholarly research more open and collaborative (Gold, 2012).

One of the most important tasks of humanities researchers is the study and publication of textual materials, known as 'scholarly editing'. One of the first steps in creating a digital scholarly edition is to digitize and transcribe the original paper manuscript. The transcriptions are then used as input for linguistic, literary or historical research, which could focus on a particular author and his/her line of reasoning, a specific topic discussed in the writings, or events of the period or region in which the manuscripts were written. High-quality research thus requires high-quality transcriptions and/or translations that are as close as possible to the original manuscript.

Transcribing and/or modernizing old handwritten manuscripts is a knowledge-intensive and time-consuming task, which is also prone to errors. First, the task is knowledge-intensive because it involves dealing with diverse and hard-to-decipher handwriting styles. This requires the interpretation of words and abbreviations based on the context of the manuscript, the peculiarities of the author's handwriting and the historical period. Second, the task is time-consuming because manuscripts vary in terms of length and condition of the paper; that is, it takes time to complete a transcription and to indicate which parts are unreadable because of damaged paper or smudged ink. And third, the task of transcribing manuscripts is susceptible to human errors because: it is easy to skip a line while reading, especially if two passages are close to each other and start with the same or a similar word; and people tend to finish off sentences or words before they actually read them completely. This is why most transcription projects, even those done by professionals, have transcripts reviewed by more than one person. The more people review a text, the more likely they are to deliver an accurate, error-free transcription.

Given the type of task, which is prone to error and requires interpretation and accuracy, and the different educational backgrounds and experience levels of citizens, it seems only natural that professional researchers in this field are concerned about quality. This provides a suitable research setting to study quality assurance in citizen science.

2.3.2 Research approach

To understand how project leaders manage knowledge work to ensure the quality of citizen science outcomes, we need to consider the activities of project leaders, their interactions with citizens, and the tasks performed by the latter. We therefore conducted a qualitative multiple-case study (Eisenhardt, 1989, 1991), where the citizen science projects are our cases and the activities performed by project leaders to ensure quality represent our units of analysis.

Using a convenience approach, we contacted two research organizations in the humanities field to which we had easy access. During familiarization interviews, our informants told us about relevant projects and whom to contact. We selected five diverse and yet representative citizen science projects, so that we could compare patterns in combining and performing activities across projects (Yin, 2014). To build an explanation (Yin, 2014) of how quality is assured in citizen science projects in general, we based the selection of projects on the most-different or heterogeneous cases technique (Patton, 2002).

The five selected projects involved citizens performing the same type of task: transcription and/or translation of handwritten manuscripts of historical value. But they differed in the type of manuscript, the transcription conventions applied, the technology used, and the characteristics of participants (i.e. size of group, background, experience, proximity) and project leaders (i.e. employed by organization vs. volunteers).

The first project, *Letters and Correspondents around 1900*, started in 2009. The project leader was a scholar in a Dutch research institute and the transcriptions were meant to be used by other humanities researchers. Participants included volunteers with a literature background and literature students at a Dutch university. Together they constituted a small community of about 10 to 20 people. The second project, *Digitizing Belle van Zuylen's Correspondence*, started in 2010 and was also led by a professional researcher and a research assistant from the same institute. Citizen contributors were, at the time of writing, members of an association interested in the work of this 18th century writer. The third project, *Gouda on Paper*, was initiated and led by one expert volunteer, with transcribing experience and an educational background in language and literature, and a professional archivist from the regional archive. The call for participants took place in November 2011 through local media. Participation is open to anyone who feels capable of performing the proposed tasks. To date, the project has about 50 volunteer participants. The fourth project, *Sailing Letters*, started in 2011 and took just over a year to transcribe about 5.800 scans from 17th-18th century handwritten documents. Participation was open to everyone who felt capable of carrying out this task. About 100 citizen volunteers contributed to the project. Finally, the *Transcribe Bentham* project of University College London started in 2010 with the aim of transcribing the handwritten original work of Jeremy Bentham, to support existing research projects. Participation is open to everyone and in the period of study (October 2012 to June 2014) about 400 people had transcribed or partially transcribed at least one manuscript, and of these 11 had transcribed 100 folios or more.

2.3.3 Data collection

We followed the activities of these five projects over a period of more than two years. Data were collected by the first author at various points in time between December 2012 and December 2015. The process of data collection was challenging, because of: the relatively small size of the projects in terms of participants, with just one or at most two project leaders each; the wide distribution of participants; and the limited number of physical meetings and training sessions. To deal with these challenges, several interviews were conducted via Skype, follow-up information and clarifications were obtained via e-mail and telephone, and numerous documents were gathered to complement and triangulate findings. Our data (see Table 2.1) consist of semi-structured interviews (over 26 hours) with project leaders and volunteer citizens, observations of meetings and training sessions (45 hours) and documents including project manuals, screenshots of website pages, news articles and other project-related documents (83 documents).

Semi-structured interviews allowed us to be consistent in the topics covered across cases and yet be flexible in adjusting questions depending on the type of interviewees and the flow

of the conversation (Patton, 2002; Weiss, 1994). The length of the interviews was about one hour on average. Interviewees were asked to describe how they became involved in the project and to give details about the project in general and their own activities in particular (see Appendices A and B). We interviewed project leaders and through them gained access to citizen participants. Project leaders explained the ways of working, provided supporting documentation, and allowed us to observe project meetings and training sessions. The interviews with project leaders took place in their offices, while the interviews with citizens were held in their homes, where they could show us where and how they normally performed the project tasks, or via Skype. Most of the interviews (27) were taped and transcribed verbatim, and notes were taken of the informal conversations.

Observations of meetings and training sessions facilitated our understanding of the activities involved in the projects and the dynamics of collaboration among participating citizens and between citizens and project leaders. Meetings included those organized by the project leaders and, for some projects, those organized by participants in order to perform the task in a group discussion setting. In general, the first author took an observer-as-participant role (Gold, 1958), which means that she did not become a member of a project or perform transcriptions (except for the *Transcribe Bentham* project). Project members knew about her presence, which allowed her to freely observe and ask questions to get to know participants, and to clarify and understand their activities. For the *Transcribe Bentham* project, in view of its characteristic crowdsourcing approach, the first author registered for the project and performed a few partial transcriptions, which gave her first-hand understanding of the type of task, its complexity and the tools used to perform it.

Table 2. 1. Data sources

Source	**Letters and Correspondents around 1900**	**Digitizing Belle van Zuylen's Correspondence**	**Gouda on Paper**	**Sailing Letters**	**Transcribe Bentham**
Interviews (formal & informal)	9	7	7	6	9
Observations*	-	6	15	-	-
Documents					
Manual (versions)	5	5	12	6	3
Website / blog	1	5	4	1	2
Other project documents	1	1	12	4	2
News articles (incl. open call)	-	1	4	2	1
Minutes of meetings	-	1	7	-	2

** Projects with no observations had no training sessions during the research period.*

We collected project documents, such as news articles, minutes of meetings and the project websites, which confirmed and complemented information from interviews and observations. We also obtained copies of project manuals, which provided information about the quality requirements of the projects, the workflow and the use of technology. Some

documents were obtained through project leaders, and others from freely accessible internet sites.

Finally, all these data, interview transcriptions, field notes of observations and informal conversations, and documents, were stored, processed and coded in the qualitative data analysis tool ATLAS.ti

2.3.4 Analysis

The analysis of data was meant to: identify and describe the multiple activities performed by project leaders to manage knowledge work and ensure quality; and explain how and why these multiple activities were connected. In other words, we aimed at explanation building (Yin, 2014).

For this purpose, first, we coded data from interviews, observations and documents to make our analytical process more manageable. Using an iterative process, we coded the activities or work practices within these projects, including the main task and supporting activities. A distinction was made between the activities performed by citizens and by project leaders. Activities performed by project leaders and other project staff included: recruiting participants; developing manuals, organizing training sessions, managing the workflow, keeping participants motivated and answering their questions; and reviewing and improving contributions. The tasks performed by citizens included: the main tasks of transcribing and translating (or modernizing) manuscripts; and supporting tasks, ranging from scanning pages and filling in metadata to reviewing transcriptions done by others. We also coded communication activities between citizens and project leaders, communication among citizens, and the use of technology and other tools (such as manuals).

Second, activities across projects were compared in terms of their purpose from a knowledge management perspective. For instance, training sessions or the use of manuals were seen as different activities intended for sharing project leaders' expert knowledge with citizen participants. The third step of analysis involved: grouping activities with the same purpose, and assessing the similarities and differences of these activity groups across projects (Eisenhardt, 1989). We compared the different ways (i.e. patterns) in which participants were recruited, how project leaders shared their knowledge with citizens, how tasks were performed, and how quality was assessed and improved. Finally, we looked for similarities and differences (Eisenhardt, 1989, 1991) among the cases to help us explain (Yin, 2014) how and why specific combinations of activities were chosen on a case-by-case basis.

2.4 Findings

By studying the five projects described above, we identified the activities used by project leaders to ensure the quality of citizen science outcomes. We also discovered how and why specific activities were combined in each project. In this section, we first discuss what information quality entails in the context of citizen science in the humanities, and the knowledge needed to perform transcriptions and translations. We then present the activities carried out in these projects according to their common purpose. An explanation of why certain activities are combined follows in the discussion section.

2.4.1 What is quality?

In the context of citizen science in the humanities, textual data are interpreted and processed by citizen volunteers. The expected result is information of such quality that it can be used in further research. In our study, we learned that quality involves two essential characteristics: accuracy, the match between processed information and the original object of research; and uniformity, the standardized way in which data is presented.

When asked to explain what a good quality transcription entailed, one project leader referred to accuracy in the following words: *"That all the letters in the old form are converted into letters in the modern form."* Similarly, one citizen volunteer explained: *"In the transcription you have these really old textual characters, so you convert them into modern day writing… so, that strange curl, is it an 'L', is it a 'B'? In the end there is only one character. It's about finding the right letter."* And another citizen said: *"for instance, the word 'immediately', that's with double 'm' but* [author] *writes it with one 'm', and you can think that you know how it should be, but it's not how it's written."* Accurate transcriptions require, at least, having the basic cultural competence to recognize handwritten characters and the structure of sentences, or in other words, being able to read and write; and being able to interpret textual characters, that is, to understand the language of the period in which manuscripts are written (e.g. Latin, 17th century Dutch, 18th century French).

Uniformity refers to the presentation of textual information in a standard manner. When talking about what makes a good transcription, a project leader explained: *"Also, following the guidelines. Because you must, of course if you work with lots of different people, well... stick to the agreements. So, for example, what do you do with indentation? And underlining? And what do you do with words that you cannot read?"* Standardization or uniformity requires participants to be aware of the rules of the field and the project, and to be thorough in applying them consistently while transcribing, translating, annotating or filling in metadata. Uniformity or standardization is important for quality because information needs to be searchable and to allow aggregation (i.e. into periods, authors, location…) in order to support research analyses.

2.4.2 How is quality assured?

To assure the quality of citizen science project outcomes, project leaders started by recruiting citizens. During the performance of the task, they influenced the quality of citizens'

contributions by: codifying and sharing their knowledge, and organizing tasks in specific ways. Finally, they all engaged in assessment activities to evaluate citizens' contributions. Table 2.2 shows the activities that project leaders combined to manage knowledge work and achieve high-quality outcomes.

Acquiring Knowledge

Acquiring knowledge resources usually refers to the activities aimed at recruiting people as employees. In citizen science, this means recruiting people or convincing them to participate in a project. In the five studied projects, we distinguished two types of recruiting approaches: a *true open call*, in the form of a public announcement of the project; and a *targeted call*, where the invitation to participate was directed only to a specific group of people. We also found that some organizations made use of both types of call. More importantly, our findings indicate that the different ways of recruiting participants influenced the number and type of people, and the knowledge they brought into the project.

The projects 'Gouda on Paper' and 'Transcribe Bentham' are cases where a true open call was used to recruit participants. In both cases, project leaders announced the launch of the project through various media and set no restrictions for participation, thus creating a greater pool of potential participants. In contrast, the projects 'Letters and Correspondents around 1900' and 'Digitizing Belle van Zuylen's Correspondence' recruited people within the networks of their respective project leaders. That is, they targeted people who they thought would be interested or who they knew possessed relevant knowledge to perform the main task. The project 'Letters and Correspondents around 1900' targeted mainly university students with a history and literature background. 'Digitizing Belle van Zuylen's Correspondence' recruited participants among the members of the long-established association dedicated to the work of this female author. Finally, the 'Sailing Letters' project mainly targeted citizens who had participated in a previous citizen science project, namely transcribing a 17th century bible, but additional people joined after hearing about the project in the media or through the project leader's network. Citizen volunteers with relevant background and experience were able to contribute even when the project already had plenty of participants to carry out the task.

Choosing between an open versus a targeted call has two major implications for the number of participants and the knowledge they bring in. First, the number of people who are likely to join a project is potentially higher in the case of an open call than if the invitation is limited to a specific group of people targeted by the project leader. The projects 'Gouda on Paper', 'Sailing Letters' and 'Transcribe Bentham' reached about 50, 100 and 400 contributors respectively with their open call approach, while the targeted call of the projects 'Digitizing Belle van Zuylen's Correspondence' and 'Letters and Correspondents around 1900' enabled them to recruit 7 and 20 participants respectively.

Table 2.2. Knowledge management activities to ensure quality

	Letters and Correspondents around 1900	**Digitizing Belle van Zuylen's Correspondence**	**Gouda on Paper**	**Sailing Letters**	**Transcribe Bentham**
Acquiring Knowledge	Targeted call	Targeted call	Open call	Targeted & open calls	Open call
Sharing Knowledge	Training Regular online comm. Manual	Training Regular online comm. Meetings Manual	Training Regular online comm. Meetings Manual	Regular online comm. Forum Manual	Regular online comm. Forum Manual
Organizing Tasks	Individual	Individual	Group discussions	Individual *rotation is part of workflow*	Individual *rotation optional*
Assessing Contributions	Peer and expert reviews	Expert review	Peer review *group*	Peer review *rotation optional*	Expert review

Second, the diversity of experience, knowledge and skills of citizens varies considerably in the case of an open call, while people recruited from specific communities are more likely to have common knowledge. Recruiting people with the specific knowledge to carry out the task, increases the likelihood that they will be able to contribute high-quality transcriptions. For example, people who know French will be more likely to submit an accurate digital transcription that is close to the original French document than those who are not familiar with that language. Hence, a targeted call increases the likelihood of recruiting citizens with the knowledge and skills needed to perform the task according to scientific quality standards. *"They are well-educated, one is a classicist, another a historian and an art historian… so they are well-educated people who can handle that."*

It is important to note that these recruiting activities are greatly influenced by the *self-selection mechanism* that operates in open participation phenomena such as citizen science, and cannot be controlled by the organization. Self-selection refers to the judgement made by citizens about the fit between their own knowledge and interests, and the topic and tasks of a specific citizen science project. In the projects we studied, both project leaders and citizen participants were very much aware of self-selection. For instance, one project leader said: *"Volunteers are not selected by me […] everyone who wants to contribute can do that […] though they should believe that they can do it."* Volunteers explained their decision to participate with comments such as: *"I have gained a lot of experience in these 20 years […] most people who enrol* [in project] *are very interested, they are well-educated. So, most of them know that they can handle this* [task]*."* Or by saying: *"I thought that perhaps I didn't know enough about him to be involved in this project, but one really doesn't need to know about him, you just have to be willing to look at his handwriting and try to figure out what he is saying."* Or commenting: *"And because we are very interested in* [author] *and because we thought that we had some knowledge that could be useful, we said: let's do it!"*. That is, they referred to the fit between the project and their knowledge and interests.

Sharing Knowledge

Following or parallel to the recruiting of citizens, project leaders engaged in a number of activities to share their expert knowledge and to facilitate communication among citizens. These activities included: training, regular online communication, manuals and providing means for participant interaction, such as meetings or an online forum.

Training activities were meant to teach participants basic transcription and annotation norms, to agree on standardization rules and to become familiar with the online tools or work environment. *"It is about a workshop we had twice. It was mainly technical, how it works, and after that we had one about how to actually use it. Because you transcribe, but how should you do that? A note here is different than when you put it on paper. How do you do that in the system?"*. That is, regardless of how knowledgeable the citizen participants were, project leaders provided training to make sure that transcriptions were standardized and to avoid problems with integrating multiple contributions. Training sessions were not intended to teach participants about the content or the language of the text, but rather were aimed at sharing project leaders' expert knowledge with regard to transcription conventions and using

the online transcription environment. The observed training meetings were hands-on sessions during which volunteer citizens transcribed and annotated texts in the online tool developed for the project. In projects where a larger number of people were recruited, training sessions at the research institute were not organized very often, and instead the project leaders chose manuals and other supporting materials that citizen participants could use before or while performing the task.

Knowledge was also shared through ***regular online communication***. Project leaders or coordinators communicated with citizen participants to answer their questions and to resolve issues that citizens encountered while performing the task. As one participant explained: *"If you are not sure about a thing or you put something, highlight it as questionable, or you do not quite understand it, you are not sure whether your reading of it was correct, you just put a little question and they will always get back to you."* And one of the manuals stated: *"In case of problems and special issues that are not covered in the manual, please contact the project leader"*. Regular communication also included instances of feedback. Feedback refers to the comments about the quality of contributions and advice on how to improve them in the future. In all projects, citizen participants very much appreciated regular communication from the project leaders, specially their prompt reaction to questions and their feedback. "*You can always turn to* [project leader] *with questions*. [Project leader] *answers quickly, I was really amazed, and if that is not the case then it is for a good reason and you get an answer quite soon. This is really nice, because you are busy* [with task] *and if you do not know something, it is really convenient that someone gives you the answer right away, then you can move on* [with the task]. *This is good, I like it."*

Meetings and ***online discussion forums*** were organized to support knowledge sharing and the interaction among citizen participants. The projects 'Digitizing Belle van Zuylen's Correspondence', 'Gouda on Paper' and 'Letters and Correspondents around 1900' were among the projects that organized meetings most often. Particularly in the project 'Gouda on Paper', where tasks were performed in groups, proximity allowed regular meetings between representatives of each group (i.e. group coordinators meeting). In these meetings, coordinators updated each other and the project leader on their group's progress, discussed problems and tried to find solutions. In the projects 'Sailing Letters' and 'Transcribe Bentham', the larger number of citizen participants and their wide geographical distribution meant that fewer face-to-face meetings were organized, and instead the projects offered the option of an online discussion forum. The online forum in the 'Sailing Letters' project was used by citizen participants to ask or answer content-related questions: *"…we have this site where everyone can ask questions and so on. I also have asked questions there myself […] all kinds of abbreviations that I did not know, so I wrote 'people, I came across this in this letter, who can help me, what does this mean?' And there were two or three people that replied and then you know it. And I have also helped other people."* In contrast, in the 'Transcribe Bentham' project, though citizens were aware of the forum, they did not use this form of communication with fellow participants. *"I know we can leave messages on each other's profiles but I don't know if it's just me or I haven't noticed a lot of people who do that."*

Making knowledge more explicit and structured (codification) is another way in which project leaders shared knowledge with citizens. For instance, rules that could be standardized were embedded in the online transcription tools in the form of metadata fields, encoding buttons, and drop-down lists of annotation categories. However, not all editorial conventions were suitable for insertion into technological artefacts. Our findings show that all projects used ***manuals*** or guidelines, as means for knowledge sharing. Manuals included rules that were too broad or subject to the specific transcription methodology that could not be embedded in the technology. The extent to which knowledge was codified and standardized in technological artefacts influenced the rules included in manuals. For instance, manuals included rules to standardize the dates, spelling and punctuation, and explained when and how to solve abbreviations. One of the manuals indicated, for example, how to enter dates: *"Look whether you can find a date on the letter and fill it in, in the order: day, month, year."* Similarly, in another project the guideline stated: *"Date: (of the letter, this order holds for all the dates in the metadata!)17531216 (letter 0010) yyyymmdd. In case the date is not complete, then write as follow: 175312??"*.

The use of manuals can be seen either as a substitute for lack of training or as an additional means to communicate transcription rules. Manuals were used during training sessions and distributed to participants *before* they engaged in the task of transcribing or translating, so that they were aware of rules and expectations. Moreover, manuals were also used *during* the performance of the task, as people referred to them in case of doubt and to make sure their contributions fulfilled the expected criteria. Finally, manuals were also essential *after* completing the task, that is, in checking whether submitted contributions followed the agreed rules and, if not, improving them accordingly.

Manuals were revised in the course of a project, on the basis of discussions during training sessions or frequently asked questions. For instance, one of the project manuals explicitly stated: *"Instructions are by definition work in progress: they are modified on the basis of questions, comments, specific user cases and new insights."* This was mainly the case during the pilot or experimentation phases of the projects, as project leaders tried to find the best way to codify some of their knowledge and to communicate field conventions and standardization rules. *"We are not there yet, so the manual is not final. Some issues will come from practice and they will be modified. That happened during the training evening, when we found some problems that we had not seen before. These have been added in the manual right away."*

The type of activities used for sharing knowledge differed depending on whether projects issued an open or a targeted call. In projects where larger numbers of distributed people were recruited through an open call, knowledge sharing relied more on online communication, especially the use of forums. Moreover, because of greater variability in citizens' knowledge and skills, manuals included more than just rules and standardization criteria, and offered extra supporting information. For example, the manual for the 'Sailing Letters' project included a detailed list of abbreviations common in 17th and 18th century documents, and links to specialized websites. Similarly, participants in 'Transcribe Bentham' had access to an online selection of examples of Bentham's handwriting. In contrast, projects that issued

targeted calls had smaller groups of participants, who were generally in closer physical proximity and had more common knowledge. Hence, these projects organized frequent face-to-face meetings and training sessions to share knowledge.

Organizing Tasks

Another activity carried out by project leaders was the organization of tasks. The way that tasks were organized varied between projects, depending on whether a project had recruited numerous distributed people with diverse knowledge through an open call, or had targeted smaller groups of people who were closer and had similar knowledge. We distinguished three different approaches to organizing the performance of manuscript transcriptions and translations: individual, group discussion, and individual rotation. These different approaches were all meant to positively influence the quality of citizens' contributions.

In projects with a larger number of people and few prior knowledge requirements, such as 'Gouda on Paper', 'Sailing Letters' and 'Transcribe Bentham', project leaders allowed or actively encouraged the informal revision of transcriptions by ***rotating*** the tasks among participants or ***discussing*** them ***in groups***. Both the group discussions and the rotation of transcripts had the same objective: having multiple people perform the main task (transcribing, translating), to improve quality. *"… as a second step we have the transcription, these have been rotated twice, still among volunteers, then is the level … it gets better all the time* […] *it can also happen that the second volunteer is not better than the first one, so he might add little to it, but it can also be that he does actually see something… you just get the chance. After that another volunteer goes over it and then it* [the text] *is removed from this process."*

The choice between rotating or discussing in groups was influenced by the physical proximity of participants and by the type of technology used in the project. That is, if the online (transcription) tool used in the project affords versioning, this will facilitate the rotation of tasks, tracking and deciding on the best transcription (or translation). If the tool does not allow versioning, rotating tasks becomes more complex and also requires more coordination among the participants. In the studied projects, the level of versioning ranged from saving different (i.e. 1st, 2nd, 3rd) versions of a transcription, keeping track of daily changes, to the more individual-level tracking of versions, including changes at the word-level. For instance, in the case of 'Gouda on Paper', the technology used did not afford individual word-level versioning. Given the unexpected number of participants and their proximity, the project leader urged citizens to organize groups. In general, a group's way of working entailed first the individual transcription (or translation) of the same text in Word; and then at an agreed date, participants met to compare their individual work, discuss it and produce the best transcription (or translation) possible. *"… everyone who translates writes his own translation and they send it to me, then I put all the versions next to each other in an overview, and for efficiency I make a fourth… let's say a conclusion […] it is not the final version but the merged text about which we discuss."* In the 'Sailing Letters' project, rotation of tasks was part of the normal workflow, which was organized in steps, and for each step the transcription versions were saved. 'Transcribe Bentham' was the only case where

individual word-level versioning was possible. Surprisingly, despite the possibility to track and reverse word changes, very few people in the project worked on transcriptions started by other people (i.e. rotation), mostly preferring to start their transcriptions from scratch. In contrast, projects based on a targeted call, such as 'Digitizing Belle van Zuylen's Correspondence' and 'Letters and Correspondents around 1900', used tools that did not afford individual word-level versioning, and citizen participants therefore mainly worked ***individually***.

Regardless of how tasks were organized – individually, through group discussion or rotation – quality was primarily accomplished through individual task performance. Some individuals proofread, assessed and improved the quality of their own transcriptions before saving or submitting them in the online work environment. One volunteer said: *"I tend to go through it two or three times to figure out what the gaps are, what have I missed out. I do that as part of a proofreading process to check it all: does it all make sense? is it something that the editors will find semi-useful at least?"* Other volunteers performed their work all in one go, very carefully, so that they felt confident enough to submit their work without proofreading, as the best they were able to do.

Assessing and improving contributions

In all the studied projects, citizen contributions were assessed and improved. The organization of these assessments was different in each project. We identified two assessing approaches: professional-expert reviews and peer-expert reviews.

Professional-expert reviews were carried out in the projects 'Transcribe Bentham' and 'Digitizing Belle van Zuylen's Correspondence'. The contributions were assessed and improved individually or by a small group of two or three professional researchers, who evaluated citizen contributions and made necessary corrections. In both projects, tasks were performed individually using an online transcription tool. However, the number and distribution of participants was greater in 'Transcribe Bentham' than in 'Digitizing Belle van Zuylen's Correspondence'. It thus seems that the project leaders had different reasons for assessing contributions with a professional-expert review. In 'Transcribe Bentham', a large number of people contributed to the project, but only a smaller group of citizens transcribed regularly and did not know each other: *"…with a larger and more cohesive user community, it may be possible to encourage certain experienced volunteers to take on limited editorial duties…"* (Causer, Tonra & Wallace, 2012, p. 131). Hence, at the time of our study, peer-expert reviews did not seem feasible. In the project 'Digitizing Belle van Zuylen's Correspondence', participants knew each other but they were a very small group. In that case, it therefore seemed more efficient to let citizens focus on the core task and leave the assessment and correction to the professional project staff.

The 'Gouda on Paper' project initially used professional-expert reviews to assess and correct participants' contributions. Over time, however, several factors made the use of peer-expert reviews a better option for the project. For instance, the experts were not sufficiently available to keep up with the number of transcriptions, and there were also more people

transcribing manuscripts than translating them, which resulted in disconnections in the workflow. Most importantly, the need to fulfil the project's goal of making transcriptions and translations available online to the public meant that all the produced transcriptions and translations needed to be assessed, corrected and published online more quickly. *"We want to ask* [research institute] *to publish the transcribed and translated texts in* [online tool]. *Before we do that, we need to thoroughly go over everything again. This should be done by people with the educational background, training or profession. We have these people in the project, spread over the different groups. We have asked them to participate in the committees that will perform this final control."* This indicates that project leaders were aware of the expertise level of participants. Therefore, committees or teams of peer-experts were organized for that purpose. One team assessed the accuracy of transcription and annotation of manuscripts, while another team checked the translations in terms of interpretation, and a third team reviewed the language of translations to improve their readability for present-day people.

Peer-expert reviews were an essential part of the 'Sailing Letters' project. Participants who had a relevant educational or professional background (history, literature, linguistics) and extensive experience in transcribing were asked to review and improve preceding contributions. Peer-experts were targeted by checking their short biography, which was usually requested by the project leader when they joined the project. Another criterion for targeting potential peer-experts was time availability. Despite the fact that there were no deadlines, because assessing and improving contributions is such a time-consuming task, participants were encouraged not to lose momentum. These assessment and correction tasks were also rotated among the peer-experts.

Finally, the way in which quality was reviewed and improved in 'Letters and Correspondents around 1900' changed during the course of the project. Initially the project had three main steps: transcription, assessment and final editing. However, the transcriptions and assessments (i.e. reviews) done by students were not always accurate and resulted in long discussions in the annotation field. Because of this, the project leader asked experienced volunteers to carry out a second assessment round. This second assessment was a combination of individual work and group discussion with the project leader. Hence, the project combined peer reviews with peer-expert reviews.

2.5 Discussion and conclusion

In this chapter, we set out to investigate how project leaders manage citizen science projects to ensure high-quality outcomes. We took a knowledge management perspective to address the research question and to examine and compare five projects. We looked at the different activities aimed at ensuring the quality of citizens' contributions, and how contributions are assessed and improved. We conclude that the way in which knowledge is acquired seems to be fundamental for deciding what quality assurance activities to use and combine. In addition, citizens' level of proximity, the characteristics of knowledge, the technology used in a project and the extent to which project leaders know citizens' background and skills also influence the type of activities used.

The contribution of this empirical study is twofold. First, it enriches current research on citizen science by explaining the process by which citizen science projects are managed and quality concerns addressed. And second, it contributes to the academic literature on knowledge management, uncovering the knowledge processes that characterize citizen science and showing the importance of knowledge assessment. In the next sections, we discuss our contributions, review the limitations of our study and propose directions for future research.

2.5.1 The quality assurance process in citizen science

Citizen science literature has drawn attention to the quality concerns of involving citizens in scientific research (Riesch & Potter, 2014). However, existing research has been limited to descriptions and classifications of single activities, without explaining how these activities work together within a project to ensure the quality of outcomes. This study addresses this shortcoming by examining in detail the activities used to ensure quality in citizen science projects.

Managing citizen science projects to ensure quality represents a knowledge management challenge. That is to say, these projects rely on the knowledge and efforts of citizen volunteers, but at the same time the knowledge divide that separates academic experts from the general public (Miller, 2001) and the uncertainty about citizens' knowledge (Franzoni & Sauermann, 2014) entail potential quality issues.

A knowledge management perspective provides the concepts and framework to explain how different quality assurance activities are connected to each other. From a knowledge management point of view, project leaders first ensure the quality of citizens' contributions by acquiring knowledge resources (i.e. recruiting citizens), sharing their expert knowledge and determining how tasks are organized. And second, project leaders decide how contributions are to be assessed and improved. These knowledge management activities together contribute to the quality of project outcomes (see Figure 2.1).

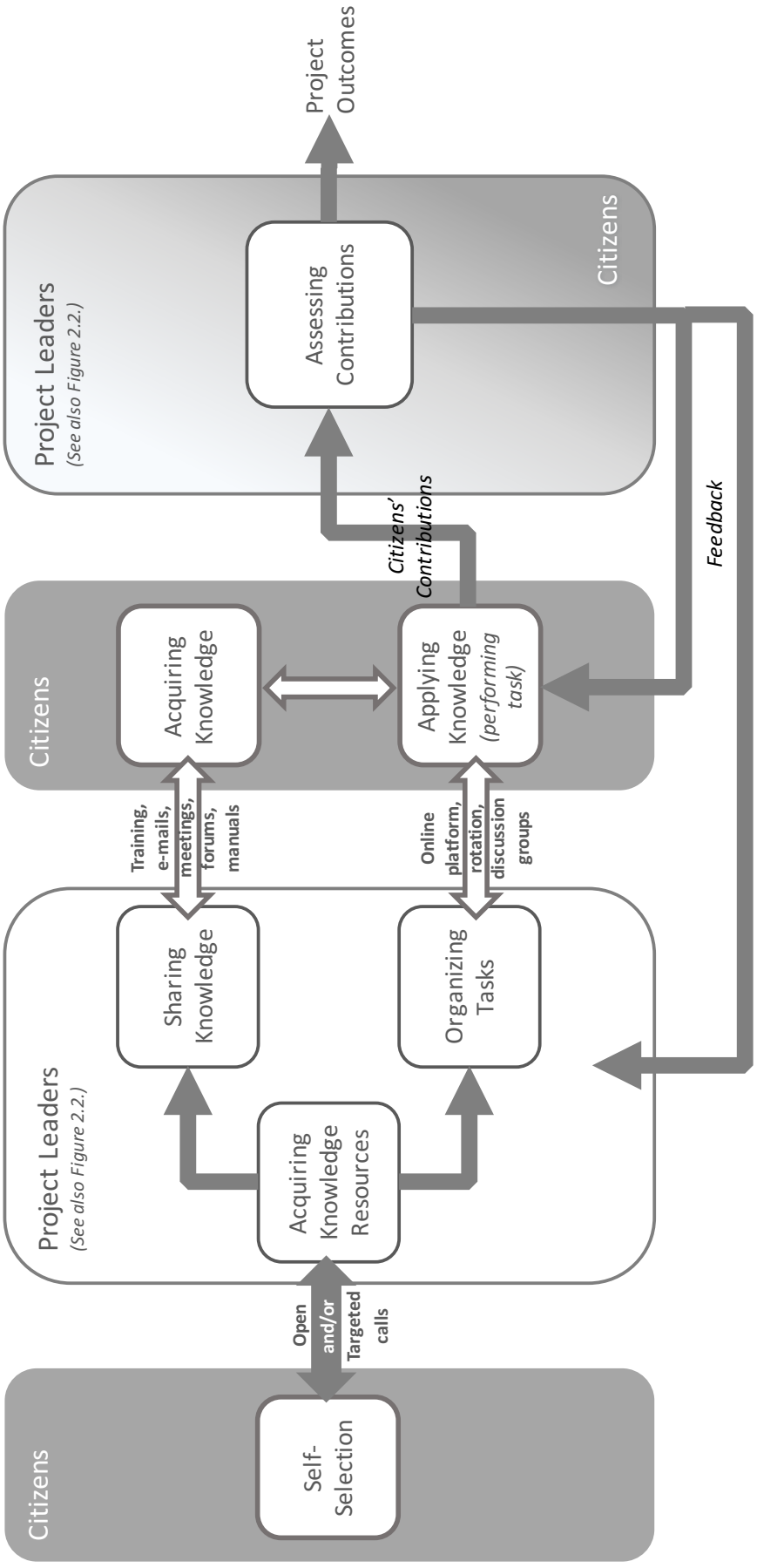


Figure 2. 1. The process of quality assurance in citizen science

2.5.1.1 Ensuring quality contributions

Acquiring Knowledge

The outcome of a citizen science project can be understood as a knowledge good produced by the collective efforts of citizens and scientists. Engaging citizens to participate in such a collective endeavour entails knowledge acquisition. That is, project leaders acquire knowledgeable human resources (Davenport & Prusak, 2000) by attracting or convincing citizens to participate in their projects and perform specific tasks. One way to reduce knowledge uncertainty and ensure the quality of citizens' contributions is to recruit volunteers through a targeted call.

Targeted calls are based on the idea that only a 'subset' of the public has the knowledge and interest to contribute to the production of scientific public goods (Wasko & Teigland, 2004). However, targeted calls contradict one of the main characteristics of modern citizen science, namely: open participation, or in other words "unrestricted entry" (Franzoni & Sauermann, 2014) or an open call (Howe, 2006). That is to say, an open call makes a project widely known and increases the chances of finding more people with potentially suitable knowledge to perform the task.

Indeed, choosing for an open call means that a potentially larger number of people can participate in a project. A targeted call, on the other hand, is more likely to lead to a smaller and more manageable group of participants with more relevant knowledge. The number of project participants has consequences for the choice of activities suitable for sharing knowledge, organizing tasks and assessing contributions (see Figure 2.2).

Sharing Knowledge

Whether participants are recruited through a targeted or an open call, engaging skilled citizen participants is not enough to guarantee quality. Citizens need to learn how to perform a task according to project requirements. Moreover, because even experts can make mistakes (Allahbakhsh et al., 2013), researchers leading citizen science projects also make sure that citizens have the necessary knowledge to perform a task and deliver quality, by sharing some of their expert knowledge with citizen participants (see Figure 2.1).

There are different ways to share knowledge, based on the distribution of people across time and space (Greenberg & Roseman, 2003) and based on the tacit and explicit aspects of knowledge (Alavi & Denford, 2011). The means of knowledge sharing in citizen science are therefore not significantly different from the activities used to communicate expertise among professional researchers. In both cases, knowledge sharing involves face-to-face interactions when there is relatively close physical proximity, and online synchronous and asynchronous communication when there are many people and they are widely distributed.

The connection between the methods used to acquire knowledge and the most suitable knowledge sharing activities lies in the number, distribution and knowledge diversity of recruited participants. Open calls are likely to result in a larger number of more distributed participants with more diverse knowledge. Hence, the activities used to share knowledge are

usually online-based and contain more examples or links to extra information sources. In contrast, targeted calls are expected to bring fewer participants with more relevant knowledge, who may perhaps be in closer physical proximity. In those cases, organizing face-to-face meetings and training sessions is more feasible (see Figure 2.2). Obviously, we should not forget that the time and resources available for a project (Riesch & Potter, 2014) also affect such decisions.

Another essential aspect in the choice of knowledge sharing activities relates to the characteristics of the knowledge to be shared. Knowledge has both explicit and tacit dimensions (Alavi & Leidner, 2001), and some means of communication are more suitable for transferring explicit elements of knowledge, while other channels are better for sharing the tacit aspects of knowledge. Systematic rules can be codified and made explicit in manuals or embedded in technology (Kogut & Zander, 1992), therefore manuals are effective for transferring explicit knowledge. Manuals help to ensure quality because they contain standardized aspects of knowledge (i.e. rules) and allow their transfer to distributed citizens (Davenport & Prusak, 2000). Other types of explicit knowledge, such as the steps of a workflow or routine, are embedded in technology (Davenport & Prusak, 2000) and support the coordination and integration of citizen contributions. But because not all scientific knowledge is as delimited and unambiguous, project leaders sometimes share knowledge through more interpersonal forms of communication (Hislop, 2009), such as meetings, training sessions and online forums.

Organizing Tasks

Sharing knowledge with citizens is an important step towards achieving quality. However, knowledge needs to be applied in practice if it is to be of value for the project (Alavi & Denford, 2011). It is in the actual performance of a task that knowledge is applied and high-quality contributions are made. Though tasks are performed by citizens, project leaders are responsible for organizing and managing that performance (see Figure 2.1).

The organization of tasks in a citizen science context is challenging, because project members do not have an employment contract that ties them to the organization, nor can they be supervised. However, this study shows that project leaders use activities similar to those applied in traditional organizations. That is, they use rules, standards, simple routines and task teams (Alavi & Leidner, 2001). The choice among these activities is influenced by the number of recruited participants and their physical proximity, as well as the affordances of technology, such as versioning (see Figure 2.2).

Projects with large numbers of participants are likely to engage in collaborative task performance, such as group discussions or task rotation. This is in line with the 'wisdom of crowds' argument that applies to the use of wikis (Bordogna et al., 2014). Quality improves as more people go over the same text. Moreover, rotating tasks or discussing in groups is dependent on the proximity of participants and the type of technology available to a project. If people are geographically close, they can work in groups. If technology affords versioning, tasks are easier to rotate.

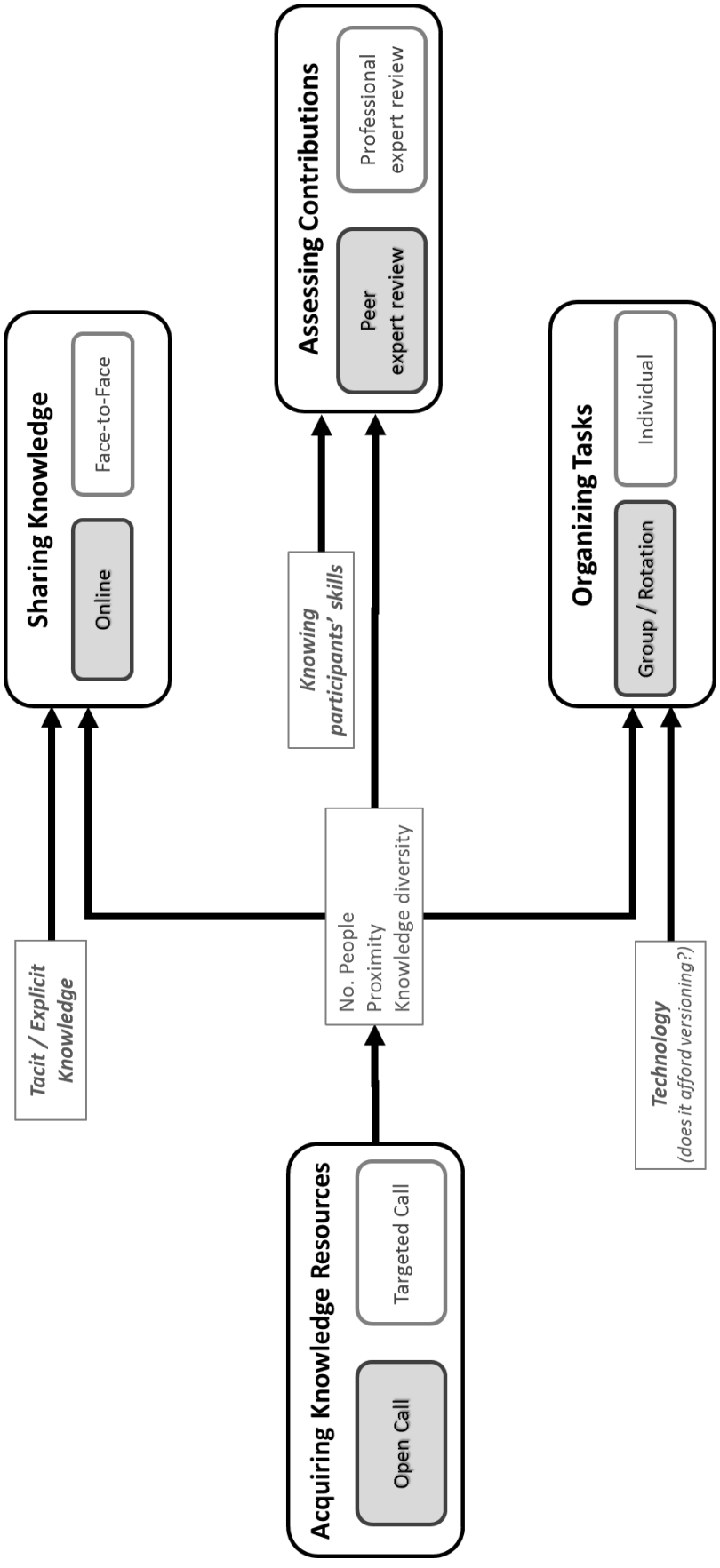


Figure 2. 2. Connection between quality assurance activities

2.5.1.2 Assessing Contributions

The last step in assuring quality in citizen science is the assessment, and correction if necessary, of citizens' contributions. The choice among assessment approaches is influenced by the number of participants and the extent to which project leaders are aware of citizens' level of expertise (see Figure 2.3). If the number of participants is small, project leaders tend to rely on 'professional-expert reviews' to assess contributions. Because professional reviews 'do not scale well' (Wiggins et al., 2011), only projects with a large number of citizen participants are likely to use 'peer-expert reviews', as long as the project leaders know participants' level of expertise.

The organization of peer-expert reviews appears also to be influenced by the way that tasks are performed (individually, rotation, groups). And, most importantly, the findings show that the usage of specific activities changes over time as projects move beyond experimental phases and project leaders learn what works best for their project.

		Knowing participants' skills	
		Know	**Do not know**
Number of Participants	**Many**	*Peer expert review*	*Professional expert review*
	Few	*Professional expert review*	*Professional expert review*

Figure 2. 3. Factors influencing the choice between professional and peer reviews.

2.5.2 Implications for knowledge management

This study contributes to the field of knowledge management by uncovering the knowledge processes that characterize citizen science and, in particular, knowledge assessment. The knowledge management literature is mainly based on knowledge processes in businesses, and to a much lesser extent in non-profit and public organizations (Hislop, 2013). Studying citizen science from a knowledge management perspective contributes to the understanding of knowledge processes in a non-profit context and brings knowledge assessment into the foreground.

The knowledge management literature has given scant attention to knowledge assessment. This is mainly due to the embeddedness of assessment in other knowledge management activities (Rasmussen & Haggerty, 2008) and, hence, the almost automatic way in which the sources and outcomes of knowledge work are usually evaluated. This empirical study sheds some light on this aspect of knowledge management. It shows how people (i.e. sources of knowledge) and their contributions (i.e. knowledge work) are evaluated in the specific context of citizen science.

Citizens are sources of knowledge who contribute their time and knowledge to perform specific tasks. To ensure quality, project leaders use targeted calls to recruit knowledgeable citizens. Targeted calls are based on the judgment made by professional scientists about

citizens' knowledge. This judgment or evaluation is influenced by prior knowledge and similar social identity (Kane et al., 2005; Lamb & Davidson, 2005). Scientific project leaders evaluate citizens on the basis of similarity between their educational and professional backgrounds. In other words, scientific project leaders base their evaluation on characteristics of their own social identity in order to reduce knowledge uncertainty (Fiol & O'Connor, 2005; Hogg, 2001), whether at the start or during the course of a project.

Citizens' contributions are an expression of their knowledge. The evaluation, acceptance or rejection of their contributions depends on the standards that characterize each scientific field or profession (Robertson et al., 2003). Hence, the assessment of citizen contributions is performed differently depending on the field and task. In the humanities, where complex textual data are processed, contributions are assessed by means of expert reviews (Brumfield, 2012).

2.5.3 Limitations and future research

Our findings may have been limited by the fact that when we started the study, the five examined projects had already begun and were at different stages of completion. We were therefore unable to observe or gain recent insights into early choices that affected the design of the project. Retrospective accounts of task design choices made before starting a project could have been biased. Because we focused on current project activities and how quality was being ensured at that moment, we are confident about the level of detail and explanation of the quality assurance process. We acknowledge the contribution of task design to ensuring the quality of project outcomes and urge researchers to study projects from their inception to take this into account.

A second constraint we faced was the difficulty in fully observing all aspects of the projects. In view of the distributed and voluntary nature of citizen science, and the part-time character of project leadership, we could not follow participants in their daily tasks. Hence, our observations were limited to scheduled meetings, trainings sessions and group discussion sessions. We believe that engaging in a citizen science project as part of the organizing team could help obtaining a better understanding of the activities and choices made to ensure quality.

The last limitation of our research relates to the variety of projects and the lack of quantitative measures. Different activities might require different time investments and coordination efforts, aspects which are sometimes underestimated (Riesch & Potter, 2014), or could result in different levels of quality. Quantitative data might allow us to track time and to define a common measure for the quality of citizens' contributions. Measuring the duration of activities and the number of errors over time could help us to compare and assess the efficiency and effectiveness of the different activities used to achieve quality. Moreover, tracking the quality of citizens' contributions over time would provide us with information about the learning effect that occurs when people contribute to a project for an extended period of time. Learning and the development of citizens' skills are also essential for quality. We expect that as citizens learn, the quality of their contributions will improve, therefore the next chapter focuses on the learning process of citizen participants.

3

Extra-organizational learning: Learning beyond organizational boundaries

"For the things we have to learn before we can do, we learn by doing."
Aristotle (384 - 22 BC)[4]

Abstract

Citizen scientists are external to research organizations, but their learning and the improvement of their contributions to scientific projects are essential for ensuring the quality of outcomes in citizen science. Organizational scholars have studied learning processes within and across organizational boundaries for years. In this chapter, we introduce the concept of extra-organizational learning to refer to the process of learning *by* external individuals who are not bound to the focal organization with an employment contract and whose tasks benefit that same focal organization. To extend current organizational learning theories, we explore one typical case of extra-organizational learning. We study the *Transcribe Bentham* project, where citizens transcribe documents of historical importance, and show how they learn by doing and by socially interacting with experts from the organization. We explain how extra-organizational learning differs from known processes of inter-organizational learning and crowdsourcing as 'distant search', and discuss implications for the organizational learning literature.

[4] *Bynum, W.F. & Porter, R (2006). Aristotle. In Bynum, W.F. & Porter, R.(Eds.), Oxford Dictionary of Scientific Quotations. Oxford University Press. Retrieved 26Sep. 2016, from http://www.oxfordreference.com*

3.1 Introduction

Organizational learning is a process of change in organizational knowledge and behaviour that contributes to organizational performance (Argote & Miron-Spektor, 2011). According to the 4I framework, an organization learns as new individual insights are shared and transformed in interaction with others, and ultimately embedded in organizational practices, routines, and systems (Crossan et al., 1999). Organizational learning does not always stop at the boundaries of an organization and may include external partners (Crossan, Maurer & White, 2011; Easterby-Smith, Lyles & Tsang, 2008).

A rich body of literature has been developed on learning across organizational boundaries (Easterby-Smith et al., 2008), mainly focusing on learning from or with other organizations. Recently, interest in *learning from individual external actors* has gained attention, as organizations increasingly learn through distant search (Afuah & Tucci, 2012) by inviting individuals to solve problems. We argue that it may also benefit an organization to encourage *learning by external actors* on whom the organization depends (Dyer & Nobeoka, 2000; Turner & Rindova, 2012).

In this chapter, we focus on *learning by external actors*. That is, we study the process where learning extends to individuals beyond the boundaries of an organization, with the specific objective of benefitting organizational performance. We refer to this process as *'extra-organizational learning'*. Key to the concept of extra-organizational learning is that learning takes place by individuals not employed by the organization. Extra-organizational learning does not focus on intra-organizational actors and processes but on external individuals who perform tasks that serve as input for the focal organization. It is therefore an extension of intra-organizational learning. In the management literature we find several examples of extra-organizational learning, for instance in service organizations where the quality of the service partly depends on users of the service learning how to perform their role or use the service (Turner & Rindova, 2012).

So far, we know little about how extra-organizational learning occurs. Given that external individuals do not have an employment contract, are less subject to organizational control, and cannot be easily socialized into the organization, we set out to investigate how their extra-organizational learning process takes place. To this end, we focus on the context of citizen science projects, where individuals are external to research organizations but their participation and learning are essential to ensure the quality of research data. Citizen participants need to learn how to contribute according to academic quality standards. Therefore, we address the following question: *How does extra-organizational learning take place in practice?*

We examined an influential citizen or crowd science case in the humanities field, the *Transcribe Bentham* project initiated by University College London (UCL). Through a mixed-methods approach to this case, we identified a condition for extra-organizational learning (retention), and two learning mechanisms (guidelines and feedback) that enable learning-by-doing and ensure the quality of contributions. In the following pages, we discuss

intra- and inter-organizational learning and how extra-organizational learning differs from them. After reviewing the literature, we introduce our research setting and case, then we present the findings of our study and conclude by discussing their implications for theory and practice.

3.2 Theoretical framework

Learning is a social and multi-level phenomenon defined as the *'interplay between social competence and personal experience'* (Wenger, 2000, p. 227). Individuals gain experience by seeking or being exposed to similar or different situations over time. New insights acquired through experience are interpreted in the context of everyday (working) life (Crossan et al., 1999; Zietsma, Winn, Branzei & Vertinsky, 2002). As interpretations of new experiences or insights are shared with others, it becomes clear how close these new insights are to socially established norms and practices, and whether learning at the individual and group level actually takes place (Wenger, 2000). Sharing experiences with others often involves joint experimentation or exploration, and using the results to adapt interpretations (feedback) or to integrate new beliefs into group activities (Crossan et al., 1999; Zietsma et al., 2002). Learning becomes 'organizational learning' when new insights are embedded into the organization's systems, practices and routines, thus when new beliefs and behaviours are institutionalized (Crossan et al., 1999).

The 4I framework of organizational learning (Crossan et al., 1999) captures the multi-level dynamics of organizational learning extending over individual, group and organizational levels. According to the 4I framework, learning involves intuiting new possibilities, interpreting these individual intuitions, integrating shared group understandings, and institutionalizing them into organizational norms and routines. Together, these processes constitute a feed-forward movement of learning from individual to group learning, constituting the exploration of new possibilities. At the same time, institutionalized knowledge may feed back to group and individual levels for exploitation. Exploration is in constant tension with the exploitation of institutionalized existing knowledge, for example by competing for organizational resources (Crossan et al., 1999; Berends & Lammers, 2010).

On the one hand, organizational learning is about exploring and gaining new and diverse knowledge. On the other hand, organizational learning is also about exploiting existing knowledge and becoming more competent and reliable (Holmqvist, 2003; March, 1991). It is generally accepted that as individuals, groups and organizations gain experience in the execution of a task, they are likely to become more effective in performing that task and deliver better results. This is the principle behind learning-by-doing or the learning curve: time and errors *"decrease at a decreasing rate as experience is gained with the task"* (Argote, 2013). Even when the accumulation of experience does not lead to improved outcomes (Huber, 1991), experience remains an essential element of learning at any level of analysis, or in the words of Argote and Miron-Spektor (2011): *"experience is what transpires in the organization as it performs its task"* (p. 1124).

As organizations specialize and become more complex, they increasingly collaborate with other organizations to innovate and achieve competitive advantage (Hislop, 2009). These collaborations are based on sharing single organizational experiences or creating joint experiences, and thus learning *from* or *with* each other (Holmqvist, 2003). This means that learning does not stop at the boundaries of an organization (Crossan et al., 2011). A clear example of inter-organizational learning is that between a manufacturer and its suppliers. Dyer and Nobeoka (2000) studied the practices that Toyota developed to facilitate inter-organizational learning, which contributed to the high productivity achieved by the company and its network of suppliers.

Inter-organizational learning literature has contributed to the field by focusing on the factors that facilitate or hinder learning across organizational boundaries. The factors usually studied refer to the characteristics of the learners, the sources of knowledge, the relationships in the process of learning, and the types of activities that are learned (Easterby-Smith et al., 2008; Ingram, 2005). Researchers studying inter-organizational relationship dynamics have examined how relational factors influence learning in different types of relationships (e.g. competitive, supplier, alliance) (Argote, Denomme & Fuchs, 2011; Easterby-Smith et al., 2008; Ingram, 2005). Learning processes differ depending on the type of inter-organizational relationship (Easterby-Smith et al., 2008) and can include: routine-based mechanisms of learning, such as meetings, work groups, training and transferring employees; the organizational orientation to collaborate with external partners; inter-organizational shared norms; informal communication; and the actions of boundary spanners (Easterby-Smith et al., 2008; Knoppen, Sáenz & Johnston, 2011).

The study of learning beyond organizational boundaries has mainly focused on learning in inter-organizational relationships. Only recently has the interest in learning from individuals outside organizational boundaries increased, as the widespread access and low cost of new technologies allow organizations to reach and learn from a great diversity of individuals with distant but relevant knowledge and skills (Afuah & Tucci, 2012). This is mainly done to tap into the existing and diverse knowledge of the crowd to support learning through exploration. Just like in intra- and inter-organizational settings (Holmqvist, 2003), learning from individuals beyond organizational boundaries can be both explorative and exploitative. Organizations not only search for new insights from the public, they also open-up their routines and involve individuals to contribute for the benefit of the organization. While learning *from* individuals outside formal boundaries has been studied as a phenomenon related to exploration (Afuah & Tucci, 2012), learning *by* outsiders for exploitation has only sporadically been analysed (Dyer & Nobeoka, 2000). In this paper, we focus on knowledge exploitation and the learning process of external individuals and groups.

In an intra-organizational context, knowledge exploitation refers to the use of institutionalized knowledge through feedback learning mechanisms (Crossan et al., 1999) to support the improvement of organizational performance. So, how does the organization benefit from exploiting institutionalized knowledge by involving external individuals? Knowledge is institutionalized when it has been embedded in the organizational culture, structure, systems and procedures (Crossan et al., 1999; Vera & Crossan, 2004). Feedback

learning mechanisms refer to the collection of activities aimed at communicating institutionalized rules, reproducing and maintaining routines, and guiding collective and individual actions towards coordinated and increasingly competent organizational performance for delivering products/services that generate revenues (Crossan et al., 1999; Popper & Lipshitz, 1998; Vera & Crossan, 2004). Examples of feedback learning mechanisms include orientation programs for new employees, the use of manuals, the communication of best practices, and reviews or checks on performance (Vera & Crossan, 2004). The question is to what extent can these mechanisms be applied to support learning by external individuals, given that they are not bound to the organization with a contract or business relationship agreement to manage their activities. External individuals are not familiar with the organization's shared norms and routines, they are not co-located, and they do not have established working hours and deadlines to facilitate their learning process. We therefore argue that to exploit institutionalized knowledge by involving external individuals, the organization engages in a different learning process.

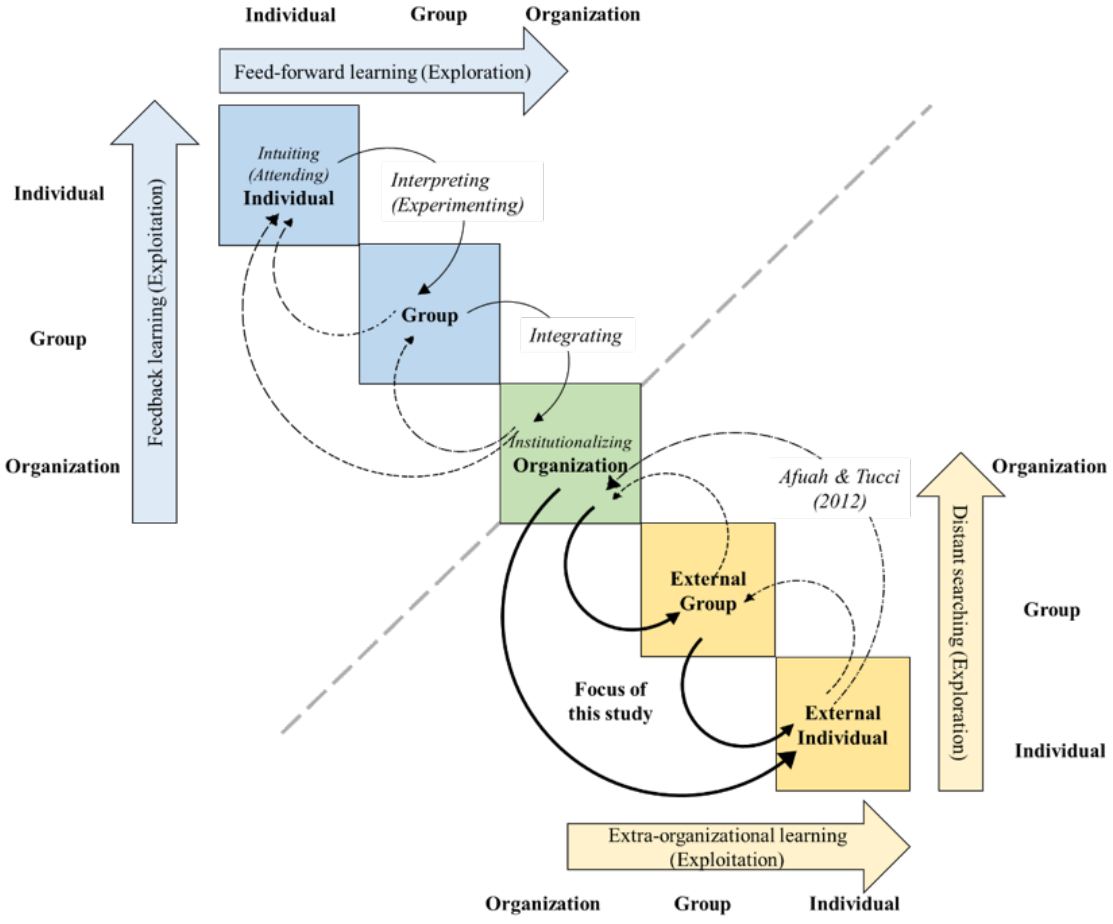


Figure 3. 1. Extra-organizational learning, mirroring the 4I framework

(Crossan et al., 1999; Zietsma et al., 2002)

We define *extra-organizational learning* as the process by which individuals who are not bound to the organization with a business or employment contract become competent in the performance of a task, the outcome of which benefits and influences organizational routines, thereby contributing to the organizational objectives. The quality of the task is essential to achieve organizational goals, whether these are better consumer experiences (Frei, 2006) or high-quality data to support scientific research (Wiggins & Crowston, 2011). Figure 3.1 shows extra-organizational learning as a process that takes place beyond organizational boundaries involving external individuals and groups. The process is presented as mirroring the feedback learning process in the 4I framework of organizational learning (Crossan et al., 1999; Zietsma et al., 2002).

We find some examples of extra-organizational learning in the management literature, especially in studies relating to (often digitally enabled) services; for instance, services where users perform part of the service work, such as: online booking of flight tickets; or self-service stores, where consumers choose products and take them to the counter. The benefits for the organization are lower labour costs and the likelihood of a better experience or service quality for the customer (Frei, 2006, 2008). The latter, however, is partly determined by how well customers perform their share of the task. This depends on the customers' needs and preferences, and the effort they put into that task. But more importantly, it also depends on the capabilities required to execute that part of the service, and the variability in customer skills.

While the existence of skill variability is essential for exploration, reducing skill variability is at the core of exploitation. Skill variability can be reduced by targeting skilled people, training people, or accommodating the task to their skills (Frei, 2006). For example, Turner and Rindova (2012) show how waste management organizations train citizens by communicating garbage preparation rules, and simplify their tasks by having consistent garbage collection times. We can say that reducing variability involves learning and requires specific mechanisms to support learning by external individuals for better organizational outcomes. Services represent one setting where extra-organizational learning takes place, but we argue that there are other situations where it applies, such as crowdsourcing.

Crowdsourcing is a relatively new form of organizing work via the Internet, and has been defined as: *"the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call"* (Howe, 2006). Despite the advantages of efficiency and knowledge diversity usually associated with crowdsourcing (Brabham, 2013), this form of organizing is not without challenges. This is particularly the case when tasks are knowledge intensive, as in research contexts in private or public organizations (Franzoni & Sauermann, 2014). Individuals participating in a crowdsourcing project are usually geographically dispersed and not bound to the organization with an employment contract; that is, they can decide when, where and how they perform that particular task. The openness of crowdsourcing also means that everyone can decide whether to participate or not. This results in uncertainty for the organization about the number of participants, the pace of task performance, and the knowledge that these participants will bring to the project. Consequently, participants in

crowdsourcing initiatives have considerable autonomy and power in their relationship with the organization.

Crowdsourcing often calls for extra-organizational learning. Organizations initiating crowdsourcing projects outsource tasks that were previously carried out within organizational boundaries to individuals who volunteer their time and knowledge to perform these tasks (Howe, 2006; Wiggins & Crowston, 2011). To ensure that contributions meet quality standards, the focal organization communicates task requirements and explains how participants should perform the task properly. By sharing this knowledge with them, opportunities for learning arise. That is, just like the organization trained its users within service settings, in a crowdsourcing context the organization educates the participants. And as these participants contribute by repeatedly performing the outsourced task they learn along the way, they learn by doing (Argote, 2013). We know little about how the process of extra-organizational learning actually happens. Therefore, in the following pages we examine how extra-organizational learning takes place and what the organization does to support learning in the crowd science project *Transcribe Bentham*.

3.3 Methods

Our aim is to contribute to theory development and to expand an existing organizational learning model (4I framework of Crossan et al., 1999) by focusing on the new concept of extra-organizational learning. Extra-organizational learning refers to the learning process that extends beyond traditional organizational boundaries and involves individuals external to the organization. To study this phenomenon as it happens in real life, we have focused on a crowdsourcing case, as a typical context in which this phenomenon occurs (Yin, 2014). Thus, we have used a case study approach to examine the phenomenon of extra-organizational learning and to contribute to theory (Yin, 2014).

3.3.1 Research setting

We have studied extra-organizational learning in the context of scholarly crowdsourcing or crowd science. Scholarly crowdsourcing projects are a suitable research setting because participants need to learn how to perform a task according to professional standards, in order for their contributions to be valuable to researchers and to become input for scholarly practices. The field of humanities (e.g. history, literature) is particularly interesting because external individuals contribute not only to data collection, but especially to the more knowledge-intensive task of data processing and analysis.

Our case study is the award-winning[5] project *Transcribe Bentham,* initiated by University College London (UCL). The aim of this project is to transcribe the collection of original manuscripts written or composed by Jeremy Bentham, a famous British philosopher and jurist, who lived in the late 18th and early 19th centuries (Causer, Tonra & Wallace, 2012).

The transcription of Bentham's work, with the intention of producing the authoritative

[5] *Transcribe Bentham* won an Award of Distinction from Prix Ars Electronica 2011 in the category 'Digital Communities'.

edition of the *Collected Works of Jeremy Bentham*, started 60 years ago. Given the size of Bentham's manuscript corpus (about 75.000 manuscript pages), the limited funding and existing technology, it was not until 2010 that, via the Internet, the online collaborative digital transcription of his writings began. The *Transcribe Bentham* project aims to increase the pace of producing transcriptions (which are used in the production of Bentham's Collected Works) and to make these transcriptions available in UCL's digital Bentham Papers repository, to facilitate public access and searching.

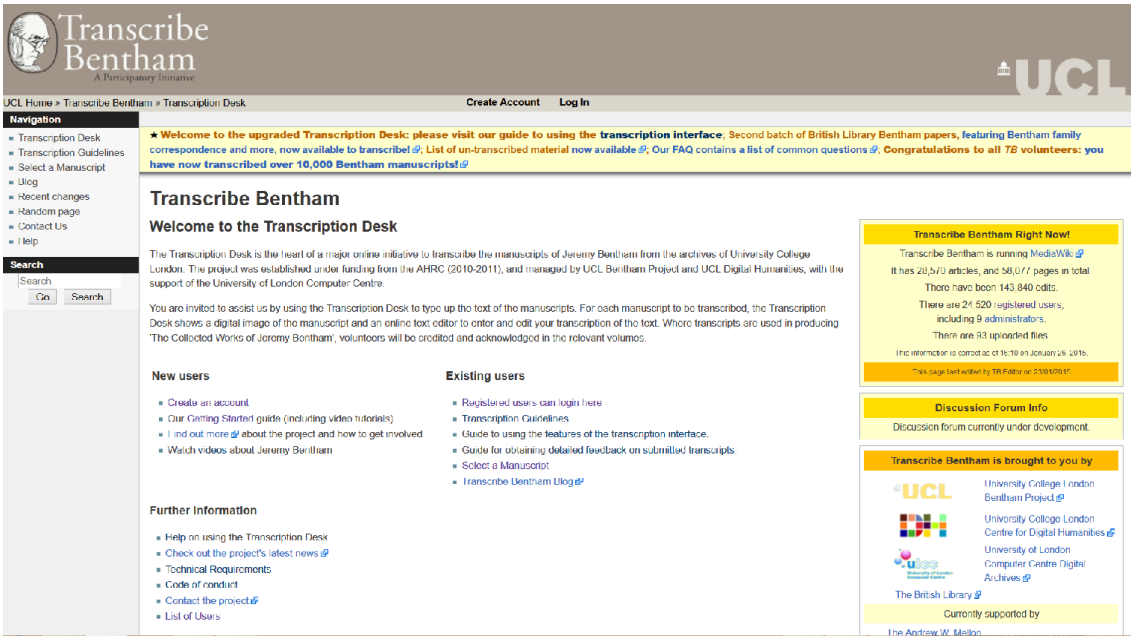


Figure 3. 2. Home-page of the Transcribe Bentham project

The *Transcribe Bentham* team of scholars created an online environment, based on MediaWiki (see Figure 3.2). This online environment allows people from all over the world to transcribe Bentham's work as voluntary participants, who do not receive any monetary reward. The task of these external participants is to literally transcribe Bentham's manuscripts. This is done in the designated transcription environment, following certain standard rules, and encoding the text into TEI-compliant[6] XML. Figure 3.3 shows the MediaWiki transcription environment, with a scan of the manuscript on the right and the transcription done by one of the participants on the left. The project is managed by two highly dedicated UCL employees, who are responsible for the communication with participants, answering questions and encouraging participation. They also act as editors by reviewing and improving participants' contributions to assure the quality of outcomes. To encourage participation and friendly competition, they have also included a ranking of top contributors on the project site.

Transcribe Bentham is an ideal case for studying how extra-organizational learning takes place, thus helping us to answer our research question.

[6] TEI stands for *Text Encoding Initiative* and refers to the community of scholars that have developed standards to program texts in digital form. Source: http://www.tei-c.org/index.xml

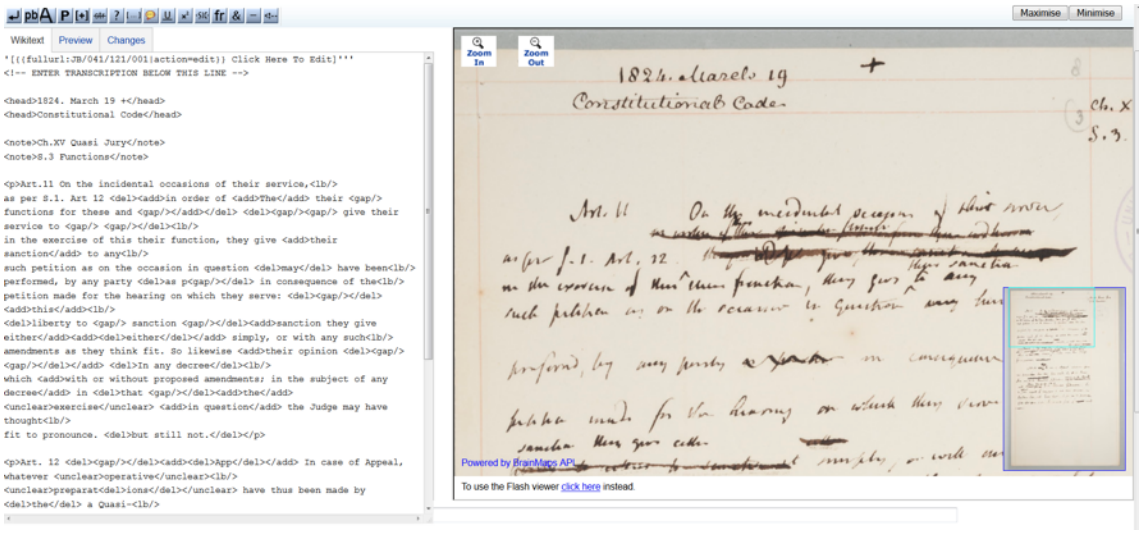


Figure 3. 3. Example of a complex manuscript, its transcription and encoding

3.3.2 Data collection and analysis

To understand extra-organizational learning in the context of scholarly crowdsourcing (or crowd science), we have used mixed-methods to collect and analyse data (Creswell & Plano Clark, 2007). A mix of qualitative and quantitative data can give us a more accurate picture of the phenomenon than if we were to rely on just one type of data (Edmondson & McManus, 2007). The data were collected and analysed in several iterative steps.

First, we collected quantitative data and started a preliminary analysis. The collection of quantitative data was carried out by the co-authors employed at *Transcribe Bentham*. The project started in 2010, but the data for this study were collected in the period from 1st October 2012 to 27th June 2014. They included data from all the participants in that period (78 people), who together submitted a total of 4.303 pages during that time. All these pages were checked and approved by *Transcribe Bentham* staff. For each transcribed page, the collected data included: number of words; level of difficulty (readability) of the handwriting; number of alterations (changes) that the editors made to participants' transcriptions; and a code to identify individual transcribers (anonymized). The level of difficulty or readability of the handwriting on each page has been classified as easy, moderate or difficult by the UCL experts. This classification is based on the period when Bentham was writing, that is, as he grew older his handwriting deteriorated, so manuscripts written between 1770 and 1789 are easier to read than those written in 1832.

These quantitative data allowed us to examine whether learning took place, and whether it benefitted the organization (i.e. UCL) in terms of the quality of contributions. We first looked at the level of participation and activity over the studied period of time. For that purpose, we used a Lorenz curve, as suggested by Sauermann & Franzoni (2015), to show the distribution of contributions among participants. For those who transcribed more than 100 pages (whom we call "super-transcribers"), we investigated how the number of alterations changed over time, as an indication of performance in terms of quality. In addition, these data also showed the accumulation of experience by these super-transcribers.

The accumulation of experience is known as learning-by-doing (Adler & Clark, 1991), which is often illustrated with experience curves. An experience curve shows the improvement of outcomes when a task is repeated over time, that is, as experience is accumulated (Argote, 2013). This information, complemented with informal conversations with the project leader, allowed us to select several super-transcribers to be interviewed.

We conducted semi-structured interviews to collect qualitative data, while continuing to analyse the quantitative data. We looked at the quantitative data in more detail to explain differences between super-transcribers and other participants. Assessing learning on the basis of performance improvements can be challenging, because other factors besides learning can affect performance (Argote & Miron-Spektor, 2011; Easterby-Smith et al., 2008). To search for alternative explanations (Yin, 2014) of the differences between super-transcribers and other participants, we examined the quality of the first attempts at transcribing and compared the means of different types of participants and different levels of manuscript difficulty.

The qualitative data were used to corroborate and clarify our quantitative findings, and to give insight into other aspects of the extra-organizational learning process. Qualitative data helped us to understand what participants consider important activities for learning. The qualitative data consisted of an archive of 4,489 e-mail notifications, notes of meetings and informal communication with the project staff, one interview with the project leader and 8 semi-structured interviews with super-transcribers. The interviews were conducted between September 2014 and April 2015 by the first author. During the interviews, participants were asked to explain how they performed the task, what made a good transcription, and what they would advise us to do if we were to contribute for the first time (see Appendix B). Notes and interview transcriptions were stored and analysed in the qualitative research software tool ATLAS.ti.

3.4 Findings

In the following pages, we first explain what quality means in this context and why it is important. Then we show evidence of extra-organizational learning and how learning results in better quality. Finally, we discuss the mechanisms used by UCL to exploit institutionalized knowledge and to facilitate extra-organizational learning.

3.4.1 Quality

Quality, as defined by the editors of *Transcribe Bentham*, includes both textual accuracy and encoding consistency of the transcriptions. *Accuracy* is related to the literal transcription of the handwritten text. Transcriptions need to be a truthful representation of the original text if they are to be valuable input for historical and textual research, and for public searching. In *Transcribe Bentham*, transcriptions must even include Bentham's mistakes, deletions and unusual or idiosyncratic spellings. Encoding *consistency* refers to the correct usage of the TEI-compliant XML codes. Uniformity in coding is important for a proper representation of the structure and features of the text, namely: headings, paragraphs, side notes, deletions, and so forth.

Interviews with super-transcribers showed that participants recognised the importance of quality as explained above. They understood that transcriptions need to be accurate: *"It's just trying to replicate and give the fullest possible representation of the original author's words and intentions as they have been placed on the parchment really, it's just... just to give it a fair representation of what they wanted to put into words, what they put into the manuscript themselves."*

Transcribers also realized that transcriptions need to be consistent and complete: *"A lot of times it's just a matter of completion. How much of the text have you transcribed, did you use the html correctly, […]be able to look at the manuscript and say: 'yep, I used the headings button right that time' or 'oh! I should fix that, I put that on the wrong block of text' kind of thing. So, it's just kind of a matter of completion, giving things as closely as transcribed as you possibly can…"*.

E-mail messages received with submitted transcriptions demonstrate how seriously participants took their tasks. They often apologized if they had not been able to complete a transcription or if they felt that the manuscript was difficult, telling *Transcribe Bentham* staff that there were *"Still lots of gaps and guesses. Sorry!"*, or that *"I've done the best I can with this one…"*. The conscientiousness of transcribers in going about the task was clear, since they sometimes felt it necessary to *"apologize in advance for any mistakes or oversights"*.

Quality is important because transcriptions are used as input for scholarly research. When participants submit higher-quality transcriptions, *Transcribe Bentham* editors need to invest less time in reviewing and correcting the submitted transcriptions. We measured quality in terms of the number of alterations (or changes) that the editors needed to make to a transcription.

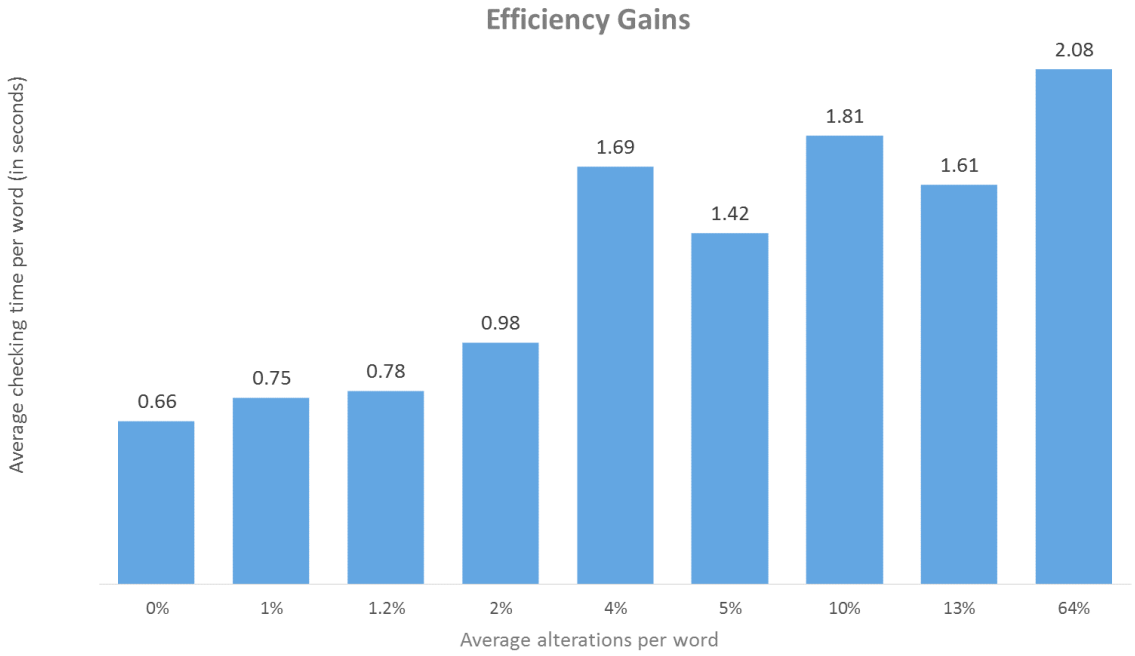


Figure 3. 4. Efficiency gains from correcting transcriptions of better quality

Figure 3.4 shows that the time spent checking transcriptions was greater when a higher percentage of alterations per word was required to ensure that the transcription was up to standard and could be accepted by the project staff. UCL benefitted from more efficient reviewing of transcriptions when quality improved, that is to say, when *Transcribe Bentham* staff needed to make fewer alterations to the transcriptions before accepting them. For example, editors reviewed and corrected an average of 18 transcriptions in one hour if they required fewer than 50 alterations each, while they could only review and correct around 3 in one hour if more than 50 alterations needed to be made to each transcription.

3.4.2 Evidence of extra-organizational learning

At the *individual level*, learning takes place as people repeatedly perform a task. Therefore, we first examine how many people participated, that is, performed transcriptions in *Transcribe Bentham*. Quantitative data show that 78 people contributed at least once in the 21-month period from 01-10-2012 to 27-06-2014. Out of all the participants, 11 contributed 91% of the transcriptions. This is illustrated in the Lorenz curve below. The distribution of contributions follows the Pareto principle, in the sense that a few people contributed the most. This is common not only in crowdsourcing initiatives (Owens, 2013) but also in online communities in general (Faraj, Jarvenpaa & Majchrzak, 2011).

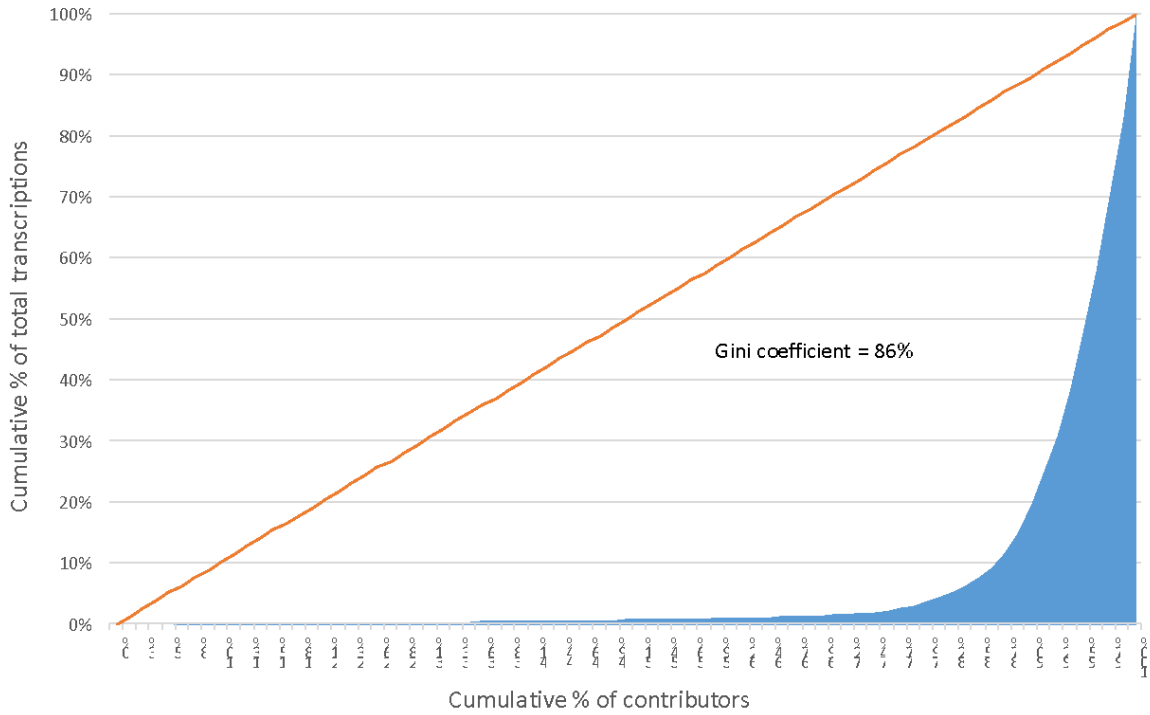


Figure 3. 5. Lorenz curve indicating the unequal distribution of participation*

**as applied by Sauermann & Franzoni (2015) in a similar context*

We refer to the 11 participants who contributed most to the project as super-transcribers. They participated in the project for a longer period of time than other participants and they submitted more transcriptions. They were also more active in terms of the number of contributions completed per active day of transcribing (2.7 on average) and had shorter

breaks or periods of inactivity (2.3 days on average) compared with other participants (2.2 transcriptions per day and 15.7 days between activity on average).

Out of the 78 people in total who contributed to *Transcribe Bentham* from 1-10-2012 to 27-06-2014, 63 started participating during that period, while the other 15 had joined before October 2012. In our analysis, we focus on the 63 people who started in this period, because we have complete data about their activity. Table 3.1 shows the measures of participation and activity for these people. In the observation period, 38 people contributed one transcription; 19 people transcribed more than one page but fewer than 100; and 6 super-transcribers transcribed 100 pages or more. Altogether, these participants contributed 1,618 transcriptions in 508 days with an average of 3.2 transcriptions per active day.

Table 3. 1. Measures of participation and activity in Transcribe Bentham

Participation and activity Measures		Total	Transcribers 1 page	Transcribers 2 to 100 pages	Super-transcribers >100 pages
Nr. of people	Started in research period *	63	38	19	6
	First transcribed page	63	38	19	6
Nr. of transcriptions	Started in research period *	1.618	38	233	1.347
	First transcribed page	63	38	19	6
Share of transcriptions	Started in research period *	100%	2%	14%	83%
	First transcribed page	100%	60%	30%	10%
Nr. of active days contributed	Started in research period *	508	38	84	386
	First transcribed page	1	1	1	1
Average transcriptions per active day	Started in research period *	3	1	3	3
	First transcription	1	1	1	1
Average duration of breaks (in days) **	Started in research period *	8,6	-	11,5	2,5
	First transcribed page	-	-	-	-

* *Participants who started transcribing in the period from 1-10-2012 to 27-06-2014.*
** *Based on people who contributed more than one transcription on different days.*

In addition to the level of participation and activity, we also looked at participants' performance in terms of the number of alterations that were made to their contributions by *Transcribe Bentham* staff (see Table 3.2). A first glance at the data shows that the transcriptions submitted by super-transcribers needed on average fewer alterations than those submitted by other participants. A Kruskal-Wallis[7] test revealed that the differences in

[7] We compared the means in the number of textual alterations per word. The data is not normally distributed and the samples are small, therefore we performed a Kruskal-Wallis test.

the average number of alterations between these three groups were statistically significant. This points to the existence of a relationship between the quality of the transcriptions in terms of alterations, and the level of participation in the project. Based on all the available data, this suggests that super-transcribers engaged in a learning-by-doing process.

We sought to explain why super-transcribers performed better than other transcribers. We thought this might be due to their prior knowledge: maybe they were already more skilled than the other transcribers when they started transcribing. They may have had more experience or better skills in deciphering handwritten texts, which might have encouraged them to do more transcriptions, whereas less skilled participants may have experienced more difficulties and might be more inclined to quit after one transcription. To check this possibility, and given the limited background information about participants, we looked at the details of the first transcriptions submitted by the participants. We compared the first transcriptions of those who became super-transcribers and those who did not (see Table 3.2). The average number of alterations in the first transcription of these groups is not significantly different. The quality or performance of the first transcription does not appear to be related to becoming a super-transcriber. We therefore ruled out prior knowledge as an alternative explanation for better performance by super-transcribers.

Table 3. 2. Learning measures in Transcribe Bentham

Learning Measures		Total	Transcribers 1 page	Transcribers 2 to 100 pages	Super-transcribers >100 pages
Nr. of alterations	Started in research period *	6.729	386	1.644	4.699
	First transcribed page	785	386	309	90
Average alterations per transcription	Started in research period *	4,2	10,2	7,1	3,5
	First transcribed page	12,5	10,2	16,3	15,0
Average alterations per word	Started in research period *	0,05	0,07	0,04	0,01
	First transcribed page	0,06	0,05	0,07	0,05

* *Participants who started transcribing in the period from 1-10-2012 to 27-06-2014.*

Another potential alternative explanation for super-transcribers performing better than the other groups of participants could be the difficulty level of the manuscripts they chose to transcribe. In general, the average number of alterations made to a transcription will differ between manuscripts considered easy, moderate and difficult and we might expect the same in the first transcription.

Table 3. 3. Selected difficulty levels

Difficulty Level		Transcribers 1 page	Transcribers 2 to 100 pages	Super-transcribers >100 pages
Easy	Started in research period *	55%	58%	50%
	First transcribed page	55%	42%	50%
Moderate	Started in research period *	29%	34%	31%
	First transcribed page	29%	53%	0%
Difficult	Started in research period *	16%	8%	19%
	First transcribed page	16%	5%	50%

* *Participants who started transcribing in the period from 1-10-2012 to 27-06-2014.*

However, the statistical analysis indicated no significant differences in the number of alterations made in the first transcription, whether this was easy, moderate or difficult. No significant differences were found either, for each of the groups of transcribers and the difficulty of the first transcribed page (Table 3.4).

Table 3. 4. Kruskal-Wallis test

Difficulty Level First Transcription	**Mean alterations per word**			**Sig.**
	Transcribers 1 page	**Transcribers 2 to 100 pages**	**Super-transcribers >100 pages**	
Easy	0.046	0.074	0.059	0.844
Moderate	0.057	0.071	-	0.833
Difficult	0.039	-	0.044	0.263

We compared the three groups of transcribers and the difficulty levels.

A final possible explanation for super-transcribers performing better overall than other participants is that super-transcribers might have chosen easier manuscripts to transcribe over time. Figure 3.6 shows the manuscript difficulty chosen by super-transcribers in their first 100 pages. Up to the first 60th pages, they selected mainly easy and moderate manuscripts, and after the 70th page, the percentage of easy manuscripts increased. In total, super-transcribers chose easy pages 50% of the time, moderate pages 31% of the time and difficult pages about 19% of the time. Therefore, the difficulty of the manuscripts does not appear to explain their performance.

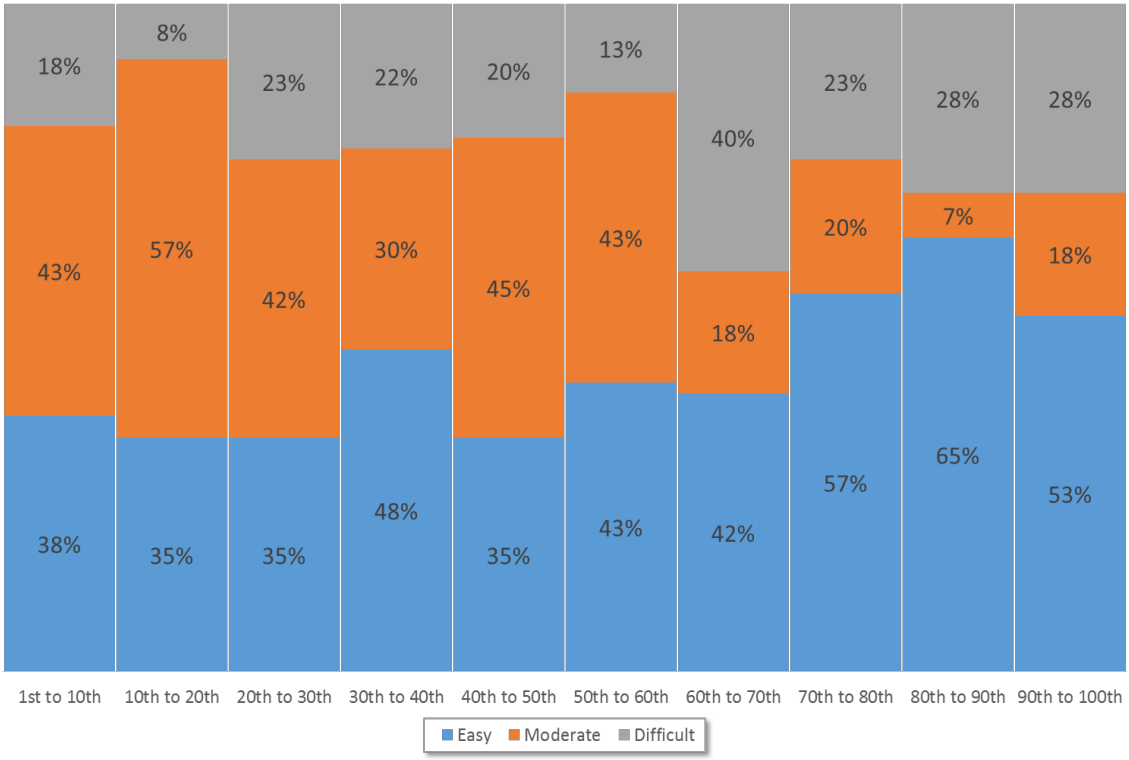


Figure 3. 6. Percentage of easy, moderate & difficult manuscripts (6 super-transcribers)

The overall performance of *Transcribe Bentham* participants is illustrated in figure 3.7. The figure shows the aggregated data for the participants who started in the period of study. We see how over time the average number of alterations per word decreased as participants gained experience and transcribed new manuscript pages. The average percentage of alterations per word decreased from about 4.4% in the first transcription to 1.5% and below after the 50th transcribed page.

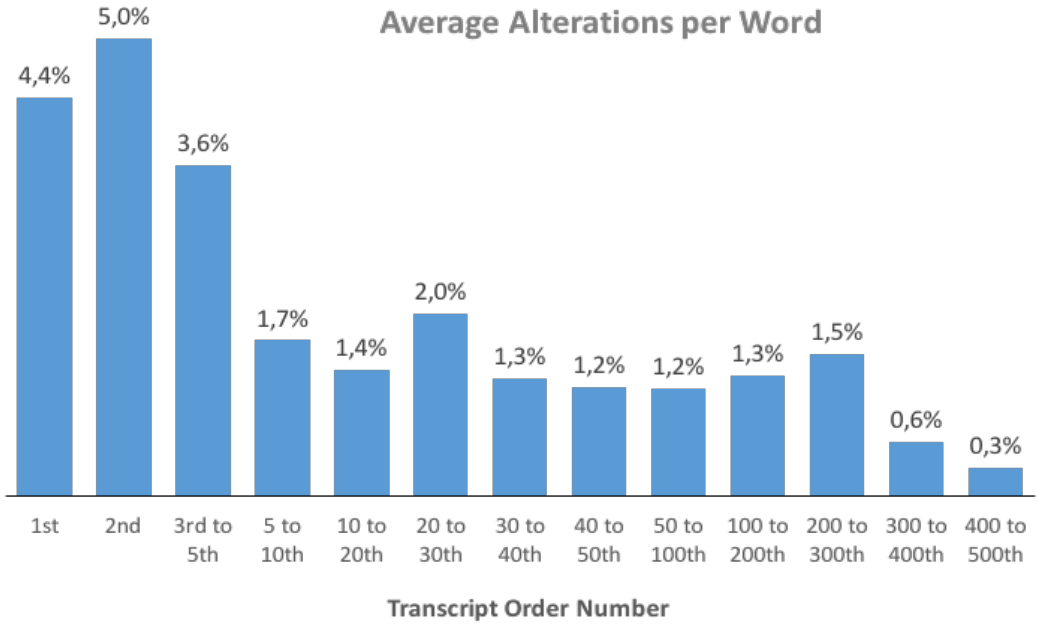


Figure 3. 7. Average % of alterations as experience increases (based on 63 people)

This shows the importance of experience or learning-by-doing at the core of extra-organizational learning. The average percentage of alterations made to the transcriptions decreases as participants gain experience. This indicates that at the *individual level*, people outside organizational boundaries who perform a task for an extended period of time become better at it, they learn and deliver higher quality.

3.4.3 Supporting extra-organizational learning

In this section, we examine the activities undertaken by the organization (i.e. UCL) to support extra-organizational learning. Transcribing historical manuscripts is a key step in the research process of humanities scholars. Transcribing involves the use of *institutionalized* practices and rules specific to the field. A 'diplomatic' transcription (i.e. literally copying handwritten text, and attempting to represent the features of the text) is one of the methods most commonly used. Though encoding text in TEI-compliant XML language is relatively new in the field of humanities (1994)[8], it is now well-established and can also be considered an institutionalized practice in the digitization of textual data. Both of these institutionalized practices need to be exploited or shared with the crowd if they are to contribute to scholarly research. This process of exploitative learning is supported by means of guidelines, feedback and community building tools.

a) Guidelines

As a crowdsourcing initiative, participation in *Transcribe Bentham* is fully Internet-based, using a customized MediaWiki environment known as the 'Transcription Desk', where scans of handwritten manuscripts are visible and transcriptions can be typed in. The Wiki also includes textual and visual guidelines for participation. These guidelines inform and instruct participants about the 'diplomatic' transcription method, point to important features of the manuscripts and explain how to use the encoding toolbar. The guidelines are simple and short, avoiding the use of jargon, but also include a section on 'Palaeography Skills', a list of words commonly used by Bentham and some visual examples of his handwriting.

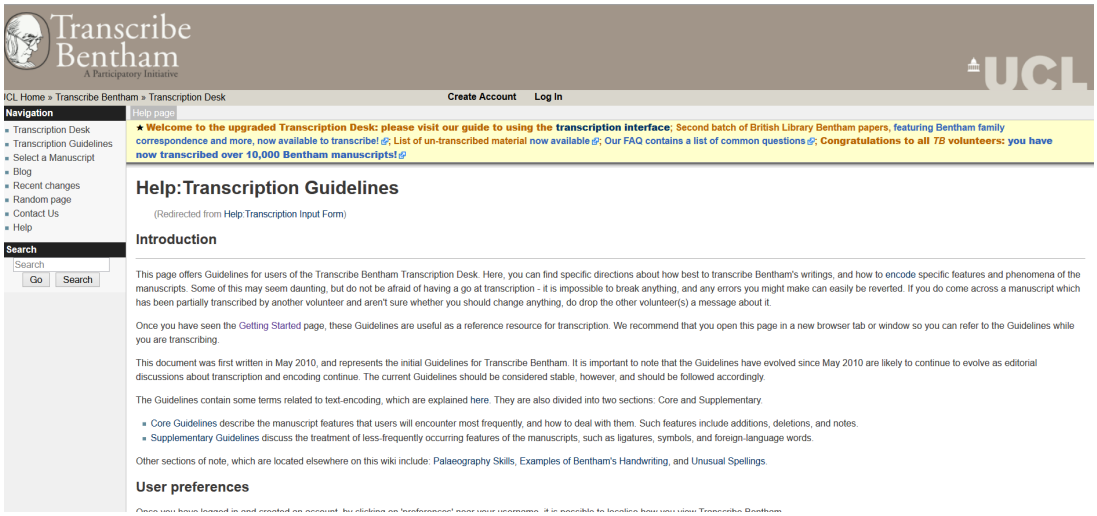


Figure 3. 8. Transcription guidelines (retrieved February 2015)

[8] http://www.tei-c.org/index.xml

The interviewed super-transcribers were well aware of the availability of the guidelines. When asked what they did after registering for the first time, the guidelines were one of the first things mentioned: *"Basically just... registering is quite quick, you set up a short profile, there is some guidance on the method of transcription, it has to be put in a particular format. […] It gives you quite a thorough little guide of how to... how it needs to be organized into digital form so that it can be useful to the project. And then you just kind of... you get through into it really…"*

And when asked what a new participant should do to learn*: "Definitely read the transcription guidelines. They are right on the side bar and they are so helpful, I relied on them so much when I was just starting out, it will tell you exactly how to use the interface, like I mentioned earlier, there are also examples of [author]'s handwriting."* However, not everyone was as keen to consult the guidelines, whether in *Transcribe Bentham* or any other project: *"… I think there was an instruction manual somewhere but I don't ever really use those, I just like to do it myself."*

b) Feedback

Another way in which UCL feeds institutionalized knowledge to the *individual level* is by giving participants feedback about their performance. Project staff members check the quality of the transcriptions by assessing accuracy and completeness. They revise the transcriptions to make sure that the gaps or words marked as unreadable are as few as possible. After reviewing and correcting the transcriptions, they provide feedback to each participant. According to the project staff, feedback is important for the general participant experience, to keep up the pace of transcription and to maintain the quality of contributions.

Feedback is provided in two ways: through e-mail messages, whose content and length depend on the number and type of alterations that were made; and through the revision history, which is a section of the Wiki that allows users to compare their submission with the project staff's revised version. The e-mails sent by project staff are intended to inform participants about the specifics of alterations made. But when submitting a transcript, the transcribers can also include a short message in which they ask questions, indicate issues with the manuscript, or request extra support from the project staff. The messages are submitted along with the transcript through the 'send a message to the editors' option embedded in the transcription area. The project staff members receive a message for each submitted transcription. They usually answer questions in the transcriber's board for the sake of convenience. Transcribers' e-mails include comments to inform the editors that it is, for instance, their first transcription: *"That was my first attempt to transcribe Bentham. I'm not sure how successful. I would be grateful for any feedback."* They also point out that a page is blank; that there are words they cannot transcribe: *"The first word in the heading eludes me";* or express their difficulties with the text: *"There is a lot of guesswork in this transcription as the handwriting is rather difficult."* Sometimes they give up on some words and share their frustration with the editors: *"I'm afraid the handwriting has defeated me on this one."* But they also ask questions about a word: *"…the word I couldn't decipher on* [manuscript] *looks like* [word]. *Is that right?";* and about how to encode: *"… in a case where there is so much hard to see, should I continue to code the empty space and unknown, or leave it the tangle that I have made?"*.

The interviewed participants mentioned the feedback they received in the form of e-mail: *"… whenever you get a message back, I get them in my e-mail… they say 'thank you for your contribution', and sometimes they mention whether they needed to fix stuff. Cause usually when they needed to fix something they mention it. And otherwise it's just 'thank you for your contribution' and then you can go back to the page that you transcribed and you can see whether and what they changed."*

They were also aware that feedback on their performance could be gained via the Transcription Desk's extensive revision history: *"I can see right under the production log that TB editor made a 57-character change to a certain document, so if I hit the difference button right next to it, I can see a page that says: 'differences between revisions of certain manuscripts' and I can see that where I added a gap of illegible text, they were able to actually see what it said and they transcribed it, added it in there. And it's just a very helpful tool to use."*

They acknowledged that the feedback received, either by e-mail or through the revision history, helped them to become better at transcribing. Some participants were really keen to know what they did wrong: *"I'm quite anxious to see if I did anything wrong, quite keen not to give people any more work than they need to. […] It is very useful to know what you did wrong."* And they also acknowledged the positive effect of feedback on their learning: *"Because the first time that I did it, I didn't know what to do with that (click), cause you know you're still trying to learn, and I sent it to the editors and they sent me their revised version back, so that I could see what I needed to do, like which codes I needed to use where, what I should have done in a different way."*

c) Community building tools

With regard to the organization (i.e. UCL) supporting community building or participants learning at the *group level*, project staff initially included a discussion forum in the Wiki. The forum was intended for giving feedback and to provide participants with a virtual space to ask each other questions and share ideas. However, the discussion forum was barely used as a group tool and there was limited interaction among participants (Causer & Wallace, 2012). The topics discussed ranged from questions about the points system (i.e. to encourage participation, people could be awarded points for the tasks performed and be included in the leader board) to questions about transcribing certain words. In general, few other participants stepped in to offer answers or suggestions in response to questions; they rather waited for the project staff to respond. Moreover, technical issues resulted in the forum being unavailable from July 2013, but no complaints were received from the participants about its absence.

Hence, the only way in which the Transcription Desk could support learning through community building was the social profile feature available to each registered user. The social profile allows participants to display information about themselves or to share any favourite Bentham-related information and material with other transcribers. The social profile also includes a "message board", where participants can post public or private messages for other project participants and add them as friends. The project editors post their standard acknowledgement messages publicly in each participant's board.

According to the project staff, there has been little communication among participants through the boards. Given that participants can send private messages to each other, it is

possible that some interaction takes place without the project staff knowing about it. However, based on the interviews held with super-transcribers, we conclude that the communication between participants has been limited: *"Yeah, they have the messages of individual users and things like that, not really done so. You can sort of add them as a friend and things like that. […] No, never used any of those."*; and, when it takes place, it mainly runs through other communication platforms like Twitter and Facebook: *"Okay, no, I haven't used that, no. Basically when I started doing it, I... you don't want anything to distract you. Yeah. I have a friend that's on there but we just talk on Facebook to one another."*

Finally, *Transcribe Bentham* organized two events or information sessions in 2011, to further engage participants. However, this attempt to get together face-to-face was unsuccessful, as only one transcriber attended (Causer & Wallace, 2012). Such low attendance, in a project where participants are dispersed around the world, is perhaps unsurprising. Nevertheless, group level mechanisms to support learning through community building do not seem to be effective in this particular case.

To summarize, participants *'definitely read the transcription guidelines'*, but they also *'have a look at what other people have completed'*, *'try to find documents that are easiest to transcribe'*, thus *'finding quite a reasonably simple one and give it a go'*, and learn-by-doing, *'as you get more comfortable just work your way up to newer documents and those documents that are harder to understand'*. That is, the organization creates opportunities for learning through guidelines and feedback, and participants make use of them to learn.

3.5 Discussion and conclusion

This paper contributes to the organizational learning literature in three ways: it expands the 4I framework by including extra-organizational learning; it uncovers and examines the specific activities that facilitate extra-organizational learning in this context; and it shows how different theoretical traditions are merged in the extra-organizational learning process. In the following pages we discuss these contributions in more detail.

First, we contribute to the organizational learning literature by expanding the 4I framework (Crossan et al., 1999) to include extra-organizational learning, and by showing other ways in which organizational knowledge flows out of the organization into the external context (Argote & Miron-Spektor, 2011). This addition to the model shows that extra-organizational learning differs from inter-organizational learning, which has been modelled as an extra level in itself (Jones & Macpherson, 2006). Our paper considers all levels of analysis: organization, group and individual.

The management literature has studied multi-level learning within organizations (Crossan et al., 2011), but has largely overlooked how learning crosses multiple levels in relationships beyond the boundaries of organizations. Organizational learning scholars have mainly focused on learning within or between organizations and have given less attention to the impact of learning beyond organizational boundaries. That is, learning *by* individuals in their roles as consumers, users or crowdsourcing participants, whose learning directly affects the performance of the organizations with which they interact. By expanding the 4I framework

to include individuals and groups beyond the boundaries of the organization, we theoretically and empirically contribute to the tree of knowledge about organizational learning (Crossan et al., 2011). We add the concept of extra-organizational learning, describe the instances in which it takes place, and explain the mechanisms that facilitate its occurrence.

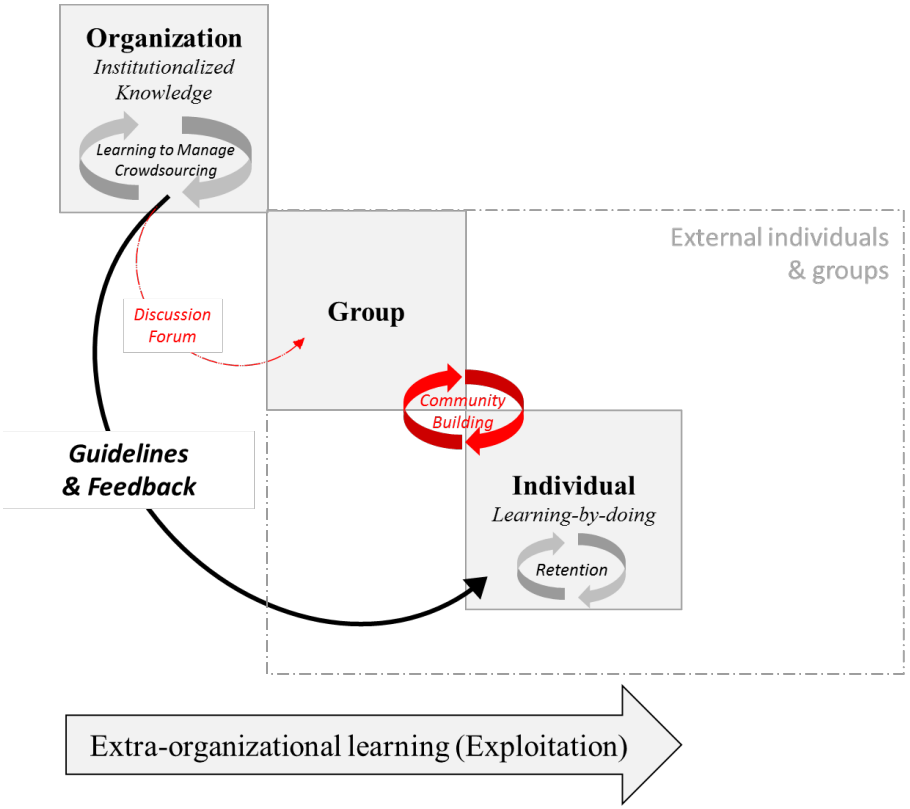


Figure 3. 9. Activities supporting extra-organizational learning

Second, we examine the activities that facilitate extra-organizational learning (see Figure 3.9). Our findings show that exploiting institutionalized knowledge enables external individual learning. The organization embeds its rules and norms into guidelines and feedback messages. Guidelines are the means by which institutionalized knowledge is codified and shared with individuals outside the organization's boundaries. In other words, guidelines facilitate the acquisition of vicarious experience before (Argote, 2013), but also during, the performance of a task. Project staff also provide feedback to participants about their performance based on institutionalized norms. Feedback can be understood as a type of 'after action review' or experience gained after performing the task (Argote, 2013). *Guidelines* and *feedback* are, therefore, different means to facilitate extra-organizational learning at the *individual level*.

We have shown that participants need to perform a task for a certain period of time in order to learn from direct experience. Consistent with the literature on online communities (Faraj et al., 2011), participation varies over time and generally only a smaller number of people become core contributors. We therefore conclude that one condition needed for extra-

organizational learning is ensuring higher participant (or user) *retention*, that is, keeping individuals engaged with the task for longer periods of time.

Supporting learning from the organizational to the *group level* has proven to be a challenge in the studied case. Despite providing a discussion forum and other social interaction features, *Transcribe Bentham* remains a crowdsourcing initiative with a small community of unconnected super-transcribers, supported by project staff. The literature about online communities indicates that the levels of participation and retention might differ depending on the purpose of a community (Ren et al., 2012, p. 846, 858). Given the purpose of *Transcribe Bentham*, participants are unlikely to have joined for its social aspects, but rather for the content and the challenge and intrinsic enjoyment of the task at hand. Hence, group level learning is not likely to occur in crowdsourcing initiatives involving independent individual tasks. Alternatively, it could indicate that, in this context, group level learning might require different supporting mechanisms.

Extra-organizational learning focuses on the learning process of individuals external to the organization. However, this does not mean that the organization does not learn from the interactions with these individuals. In *Transcribe Bentham*, project staff have learned to set-up, manage and adapt the processes and tools used in the project, and over time they have become more efficient at managing the project (Causer & Terras, 2014).

Finally, our study also contributes to current organizational learning studies that merge different research traditions (Argote, 2011). We provide empirical evidence of how the 'learning curve' and sociological traditions of organizational learning come together in the organization's external context. Our research demonstrates that at the *individual level*, learning takes place when external individuals gain experience by repeatedly performing a task assigned by the organization: *learning-by-doing* (i.e. learning curve). At the same time, the organization facilitates learning by providing guidelines and feedback. We regard these guidelines and feedback as instances of virtual *social interaction* between the individual and the organization. Learning is said to be *"a dynamic, two-way relationship between people and the social learning systems in which they participate"* (Wenger, 2000, p. 227), that is, learning occurs at the intersection between individual experience and social interaction. In our context, this two-way relationship takes place online between people outside the organization, who individually accumulate experience, and the organization as a social system with its established rules and communication practices. In this context, learning takes place at the periphery of professional practices (Wenger, 2010, p.131-132). Participants in scholarly crowdsourcing initiatives are often nonprofessional scientists, but people with a marginal position (Jeppesen & Lakhani, 2010, p. 1019) or outsiders who temporally participate in scientific research. These individuals gain peripheral access (Wenger, 2010, p.132) to professional research practices by participating in crowdsourcing projects. They learn by performing tasks that belong to the professional research practice, but they rarely become full participants.

3.5.1 Limitations and future research

Despite the limitation of our research being based on just one case study, we believe that our insights are valid both in the context of crowdsourcing and in other situations involving individuals connected to the organization without an employment contract. As we have explained, also in the context of services, organizations educate their consumers in performing their part of the service to achieve a good quality service experience.

Our study suggests two possibilities for future research. First, we expect that reducing knowledge variability by simplifying the task (Frei, 2006) might speed up learning, and engage and retain more people. Future studies could examine whether simplification of the task contributes to accelerated learning and retention of participants, or conversely leads to individuals quitting due to lack of challenge. And second, the anonymity to which participants in online-based endeavours are entitled has limited the analysis of relationships between educational background, prior experience and individual performance. New studies in a similar setting should consider including a few compulsory fields in the registration of participants, to allow such analyses without compromising privacy.

3.5.2 Practical implications

This study has shown that the progress made in the *Transcribe Bentham* project is mainly due to the dedication of the project staff in maintaining good relationships and clear communication with participants, and the effort of a small group of enthusiast super-transcribers, who offer their time and knowledge to transcribe the complex manuscripts written by Jeremy Bentham. Though the single transcriptions submitted by hundreds of other contributors are extremely valuable, our findings indicate that the project would benefit from higher quality and faster completion time if more one-time contributors were motivated to continue in the project for longer periods of time.

Project staff have focused on reducing capability variability among the participants and ensuring quality by targeting skilled people through publicity[9] in higher education and humanities blogs, journals and websites, and by offering guidelines and feedback to participants. However, our study indicates that this is not sufficient to ensure greater participant retention. In line with Frei's (2006) recommendation to break the trade-off between reducing and accommodating to the crowd's capability variability, we believe that a project could attract more people with different skills by customizing the task to fit those skills. Customization could be achieved through simplification, by dividing the manuscripts into smaller chunks of text, or by progressing through difficulty levels. We conclude that achieving high-quality contributions from external individuals and groups entails creating opportunities for extra-organizational learning. That is, organizations need to enable experiential learning by retaining external individuals and educating them on how to perform their role or task according to specific standards.

[9] Publicity includes the announcement of the project in several media, and the exposure gained from press and TV reporters contacting the project. See: http://blogs.ucl.ac.uk/transcribe-bentham/publicity/

4

The dynamics of affordances: Using an online citizen science platform

"All roads lead to Rome."
Alain de Lille (c. 1128 – 1203)[10]

Abstract

In this chapter, we examine the use of a web-based citizen science multiple-project platform and explain why it is used differently than intended by its designers. For this purpose, we build upon the theory of affordances. We propose a framework that distinguishes between designed, perceived and actualized affordances, and that situates affordances within activity systems. The framework is based on activity theory, and is used as an analytic tool to study technology use in a citizen science project. By applying the framework to analyse an empirical case, we demonstrate (1) that it is possible to distinguish between designed, perceived and actualized affordances, (2) that technology is more likely to be used differently than intended when these different types of affordances emerge within different activity systems, and (3) that technology can be used in different ways to achieve the same objective. In our case, in order to achieve quality outcomes, a web-based citizen science platform is used as a repository instead of as an online work environment. The platform's designed affordances are part of the activity of technology developers and emerge in the relationship between these developers and the technological artefact that they create. Perceived affordances arise within problem-solving activities, that is, they are learned when managers or project leaders interact with technology as a potential problem-solving tool. Finally, affordances are actualized when people perform technology-mediated actions that are consistent with their activity's norms, community and division of labour, and compatible with other used technological artefacts.

[10] http://en.antiquitatem.com/all-roads-lead-men-to-rome-viae-romanae

4.1 Introduction

It is generally accepted that individuals often use technology in ways other than intended by its designers (Azad & King, 2008; Koopman & Hoffman, 2003; Majchrzak & Markus, 2013; Orlikowski, 2000). But why do they do that? This is a question that students of technology and organizing often ask when examining the use of new technological artefacts in organizational contexts. Social-constructivists have pointed to values and attitudes, technological frames, work practices, roles and relationships as important factors influencing the choice and use of technological artefacts (Leonardi & Barley, 2010). However, social-constructivists are criticized for giving scant attention to how technology itself influences how it is used (Leonardi & Barley, 2010). That is to say, any line of research aiming to study technology and organizing, should not only consider the effect of social interactions on the use of a technological artefact, but also take into account the role of the artefact's own material properties (Leonardi, 2012).

Researchers have made significant efforts to bring technology's materiality back into the picture (Orlikowski, 2007; Leonardi, Nardi & Kallinikos, 2012). Some of them have done so by introducing the notion of affordances, as a bridging concept between the social and material aspects of technology and organizing. Technology affordances refer to potential actions that human actors can accomplish by using technology (Majchrzak & Markus, 2013). The perception of different affordances is said to explain why the same technology is used in different ways (Faraj & Azad, 2012).

However, the theory of affordances does not explain precisely how affordances turn into specific technology uses (Strong et al., 2014; Zammuto, Griffith, Majchrzak, Dougherty & Faraj, 2007). In other words, we do not know much about the process of actualizing affordances (Strong et al., 2014), how the potential for action turns into actual technology-mediated action. Recent research contends that the actualization of affordances is influenced by individuals' goals and the contextual or work conditions in which potential actions might take place (Bygstad et al., 2016; Strong et al., 2014). Yet, individuals' goals (Markus & Silver, 2008) and context (Faraj & Azad, 2012) are essential to the concept of affordances in general. Hence, the way in which affordances are actualized remains unclear.

A means to clarify how affordances are actualized might be to situate this concept within the context of human activities or activity systems (Kaptelinin & Nardi, 2012) and to differentiate between designed, perceived and actualized affordances. To this end, we focus on the following question: *How does the distinction between designed, perceived and actualized affordances help to explain the use of technology in unintended ways?*

To answer this question, we propose an analytical framework that builds upon activity theory, and illustrate its application with one empirical case. The studied case is a citizen science project, the overall activity of which is driven by the objective of transcribing and translating texts written before 1800, according to scientific quality standards. The analysis focuses on the project's use of a web-based platform to integrate the contributions of multiple groups of citizens and make them available online. The application of the

framework shows that it is possible to distinguish between designed, perceived and actualized affordances. It also indicates that technology is likely to be used differently than intended when these different types of affordances emerge within the distinct and yet interrelated activity systems of technology designers, managers and end users. In the following pages, we review the concept of affordances and introduce our activity theory-based framework. We then apply the framework to analyse the case of a citizen science project and the use of a web-based multi-project platform.

4.2 Theoretical background

Technology is often used in ways other than expected by the people who design or implement it. For years, such unintended uses were considered problematic because technology was treated as a given and individuals and organizations were expected to change their way of working accordingly, a view known as technological determinism (Leonardi & Barley, 2010). Since the 1990s researchers have come to understand these differences by focusing on the social processes of technology development, implementation and use, that is, social constructivism. However, in their aim to differentiate themselves from technological determinism, constructivists have paid less attention to technology itself (Leonardi & Barley, 2010). To deal with this issue, a new research stream has emerged which distinguishes between the materiality of technology (i.e. its form and matter) and the potential actions that technology allows human actors to perform (Leonardi, 2012). These possibilities for action represent the bridge between the material and social aspects of technology and organizing, and are also known as 'affordances'. Focusing on affordances allows us to understand the use of technology in organizations by paying equal attention to the material and social aspects of technology and organizing (Faraj & Azad, 2012).

4.2.1 Affordances

The concept of affordances was devised by the American psychologist James Jerome Gibson in the late 1970s, referring to the possibilities for manipulating, using or acting upon the physical properties of objects, people and living creatures, in relation to the person or animal perceiving these properties (Gibson, 2014). Since then, the concept of affordances has been further developed and used not only in the field of psychology but also in technology design (Norman, 2013) and technology and organizing (Markus & Silver, 2008).

In the literature of technology and organizing, affordances (see Figure 4.1) refer to the possibilities for goal-oriented action that result from the interaction between human actors and technology (Faraj & Azad, 2012; Hutchby, 2001; Markus & Silver, 2008; Zammuto et al., 2007). Affordances refer to both the *functional* and the *relational* properties of technology. Functional, because technology can facilitate or limit certain actions, and relational, because supporting or limiting these actions is related to and depends on the point of view of different people in different circumstances (Hutchby, 2001). That is to say, possibilities for action emerge as part of the relationship between the materiality of technology and the ability of people to distinguish these possibilities in a given context (Markus & Silver, 2008).

Figure 4. 1. Affordances as a relational concept

While the core of the affordances concept as 'possibilities for action' has remained the same over the years, academics differ in their understanding of how this aspect of the human-technology relation occurs in practice (McGrenere & Ho, 2000). For instance, while Gibson's original contribution was based on the idea that affordances 'are perceived directly' or visually (Gibson, 2014, p.131), Norman emphasized their cognitive perception (Norman, 2013, p.12). Moreover, the focus of research has shifted over time, from the emphasis on perception (Gibson, 2014; Norman, 2013) to the more recent attention to the enactment or actualization of affordances (Leonardi, 2013; Strong et al., 2014). These differences in the understanding of affordances, and the shift in research approaches, may be attributed to the various disciplines and research agendas of those using this concept (Kaptelinin & Nardi, 2012). However, we believe these differences might also be due to the fact that the theory of affordances is a relatively new approach in the study of technology and organizing (Majchrzak & Markus, 2013) and as such, some aspects of this theory are still being explored. To contribute to the further understanding of technology affordances and the practical applicability of this concept, we propose a framework that both differentiates and integrates designed, perceived and actualized affordances in context.

4.2.2 Analytical framework

The framework that we propose is intended as an analytical tool to investigate whether it is possible to distinguish between designed, perceived and actualized affordances, and whether such a distinction helps to explain why in some situations technology is used differently than intended.

We argue that the analysis of the process by which affordances are perceived and subsequently actualized (or not), ought to start by explaining 'designed affordances' because these refer to the intended use of technology (Bærentsen & Trettvik, 2002). Don Norman, who introduced the concept of affordances in the field of technology design (Faraj & Azad, 2012), claimed that "*to be effective, affordances and anti-affordances have to be discoverable – perceivable"* (Norman, 2013, p. 11). In fact, he explicitly pointed to the need for specific clues or signifiers to be embedded in technological artefacts, to help people understand what they can do with them (Norman, 2013). Signifiers are material properties of a technological artefact that are built into it by its developers to indicate the artefact's affordances or action possibilities. In other words, technology developers use signifiers to define technology's intended use or 'designed affordances'. Therefore, the study of affordances should start by identifying this intended use.

The fact that technology includes signifiers pointing to specific potential actions does not mean that users will perceive the same action possibilities as intended by designers (Bærentsen & Trettvik, 2002; Bygstad et al., 2016). This is mainly because, in the process of designing, potential users are often pictured as archetypal groups of people (Faraj & Azad, 2012, p. 251).

Though affordances can exist whether they are perceived or not, they can only become actual actions if they are perceived by someone who can benefit from performing those technology-mediated actions (Volkoff & Strong, 2013). This brings us to the first step in the process of turning potential into action, namely the perception of affordances (see Figure 4.2).

Perceiving affordances

Perceiving affordances means *"being aware of the existence of an action possibility"* (Bernhard, Recker & Burton-Jones, 2013, p. 5). The range of possible actions that an individual can perceive in a technological artefact are said to depend on the characteristics and goals of the individual and the materiality of the artefact, as well as the affordances that were designed into it (Hutchby, 2001; Markus & Silver, 2008). That is, the different characteristics of human actors, such as age or physical qualities (Gibson, 2014), and different innate and learned abilities (Faraj & Azad, 2012) result in different perceived affordances. Therefore, affordances are *relational*. The materiality of a technological artefact is understood as the form and matter that constitute this artefact, the combination of which does not change over time or across contexts (Leonardi, 2012). It is the perception of materiality that enables or limits the range of potential actions that are perceivable by human actors. This is also referred to as the *functional* aspect of affordances (Hutchby, 2001).

However, perceiving affordances is not enough to explain the actual use of technology (Bygstad et al., 2016). That is, though affordances might exist whether someone experiences the artefact or not, or even if no specific actor perceives them (Bygstad et al., 2016; Volkoff & Strong, 2013), they only lead to actions if they are actualized.

Actualizing affordances

While the design and perception of affordances have been extensively discussed in the literature on technology design (Norman, 2013), and in studies of organizational change (Leonardi, 2011, 2013), less attention has been given to the process by which affordances are enacted or actualized (Strong et al., 2014). The actualization of affordances entails: *"turning possibility into action"* (Bernhard et al., 2013, p. 5); in other words, users perform the actions that were once thought possible by using a particular (technological) object.

A review of current affordances literature points to two essential factors that influence the actualization of affordances: individuals' intentions or goals, and contextual conditions. To turn possibilities into actions, individuals need to have specific intentions or goals that can be achieved by using the technology in the way that they envisioned as possible (Volkoff & Strong, 2013, p. 822). In addition, the organizational context or work conditions in which

possible actions are expected to take place might include structures that either facilitate or inhibit specific technology use (Bygstad et al., 2016, p. 87; Strong et al., 2014, p. 72).

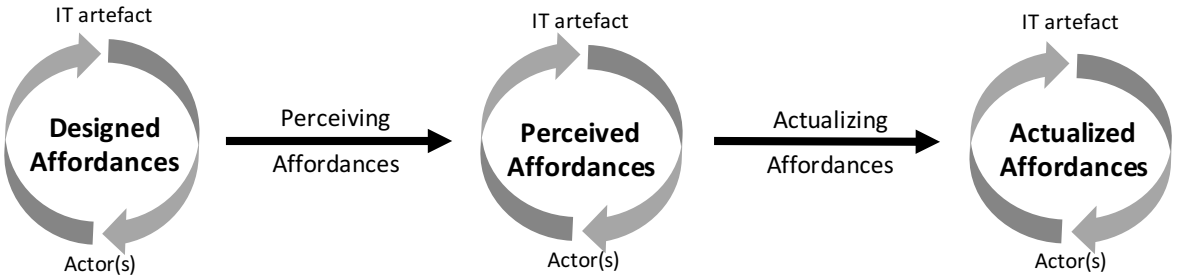


Figure 4. 2. Analytical framework

However, as we explained above, individuals' goals and contextual conditions not only influence the actualization of affordances but are also essential aspects of the concept of affordances itself (Faraj & Azad, 2012; Kaptelinin & Nardi, 2012). That is, affordances are possibilities for **goal-oriented action** that result from the interaction between human actors and technology in a **specific context**. Therefore, the process by which affordances are actualized remains unclear. It has been said that affordances are "*constitutive of and instantiated within materially-bound practices"* (Faraj & Azad, 2012, p. 254). Hence, to understand actualization, we need to situate affordances in the context of the organizational practices in which potential actions are designed, perceived and actualized (Kaptelinin & Nardi, 2012). For this purpose, we add to our framework the principles and terminology of activity theory.

Activity theory is a useful conceptual framework for analysing phenomena at different levels: activities, actions and operations (Kaptelinin & Nardi, 2006). Given that affordances are defined as 'potential for action', it makes sense to use a framework that allows us to focus on activities and their underlying actions. Moreover, activity theory is based on the principle that activities (and hence, actions) are mediated by both social and material factors (Kaptelinin & Nardi, 2006).

Affordances embedded in activity systems

Using activity theory as an analytic framework allows us to place affordances in the context of an unfolding activity. It allows us to link technology affordances to the aspects of the activity in which they emerge. One can simultaneously link affordances (potential actions) to the subject who performs that action, the object upon which the actions is applied, the social and the material structures that influence the potential action. Taking an activity theory perspective, situates affordances within the activity system of a focal organization (see Figure 4.3). Proponents of activity theory refer to affordances as *"features of activity systems"* (Bærentsen & Trettvik, 2002, p. 54) or as being *"contextualized in unfolding activities"* (Kaptelinin & Nardi, 2012, p. 3).

A system is defined as *"a perceived whole whose elements 'hang together' because they continually affect each other over time and operate toward a common purpose"* (Senge, 1994, p. 90). In an activity system, human actors, the object towards which their actions are directed, as well as social and material structures and all the interactions between them, together constitute the system in which (potential) action takes (or will take) place (Allen, Brown, Karanasios & Norman, 2013; Engeström, 1990, pp. 77-79; Nardi, 1996, p. 76).

The **subject** in an activity system refers to the actor or actors from whose perspective the activity is analysed (Engeström, 1990). The activity performed by these actors is driven by an **object**, which can be understood as the desired outcome that motivates the performance of that same activity (Kaptelinin & Nardi, 2006). **Actions** are part of the activity and are carried out to achieve the desired outcome (Kaptelinin & Nardi, 2006).

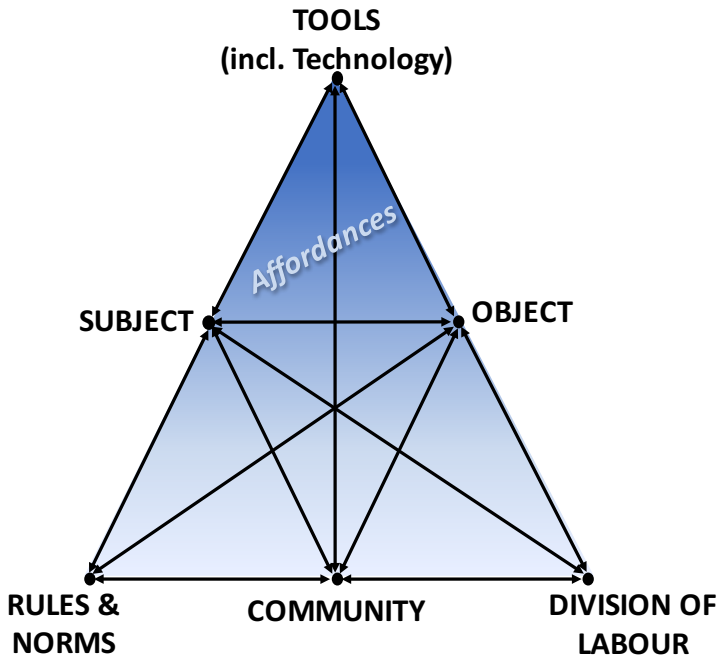


Figure 4. 3. Affordances embedded in an activity system

The **social structures** that characterize an activity system include: rules and norms, a division of labour, and the community of people who are involved in the activity (Engeström, 1990). Through social interaction with the **community** of people directly or indirectly involved in an activity, individuals develop a set of assumptions or expectations about a particular technology (Leonardi, 2009; Orlikowski & Gash, 1994). These interactions can either be informational, involving the sharing of information about experiences with that technological artefact; or normative, including expectations about the user's actions with the technology (Karahanna, Straub & Chervany, 1999). In addition, the interaction between actor(s) and community is governed by **rules and norms**, which are understood as the *"appropriate and expected behaviour"* (Fayard & Weeks, 2007, p. 614) within a specific activity or organizational setting. Consider the example given by Faraj and Azad (2012, p. 253) concerning the entertainment potential of a computer game that can be perceived and actualized at home, versus the failure to perceive and actualize it in the context of a school

class. Norms are also related to the **division of labour** and the community of people who participate in any human activity (Engeström, 2000; Engeström & Miettinen, 1999). For instance, following Fayard and Weeks' (2007) example, while in one organization the norm may be that everyone performs a certain task (e.g. copying), in another setting that task is normally entrusted to people with a specific role (e.g. secretaries), resulting in both a different division of labour and different patterns of behaviour. Though the potential for action exists for everyone in an activity system, a specific division of labour may result in affordances being perceived and actualized by some people but not by others. To sum up, given different arrangements of social structures, some affordances may emerge and be actualized in one setting but not in another.

An activity system also includes a variety of **material structures**, also referred to as signs, tools and/or technologies that mediate action (Engeström, 1990). We argue that the use of a new technological artefact takes place in relation to this array of tools or technologies. Leonardi (2009) has drawn attention upon to this relation, and refers to it with the term 'material interactions'. The point is that the use of a technological artefact is influenced by the use of other artefacts and the comparison of their corresponding affordances (Fayard & Weeks, 2014, p. 243, referring to Gaver, 1996). If one technological artefact offers the same action possibilities as others, whether it is used will depend on how efficiently and/or effectively it supports that action compared with the others (Leonardi, 2009). Hence, the existing technologies within an activity system will influence the affordances that are perceived and/or actualized and those that are not.

In the following pages, we describe our research methods, and then apply our framework to an empirical case to assess whether it is possible to distinguish between designed, perceived and actualized affordances. In this process, we use activity theory to analyse the context in which affordances are designed, perceived and actualized. Finally, we discuss the implications of our framework.

4.3 Methodology

The aim of this chapter is to explain why technology is sometimes used differently than intended. We address this topic by focusing on the concept of affordances, integrating the concept within an analytical framework and applying this framework to an empirical case. As part of a larger qualitative multiple-case study, we have examined several citizen science projects that use the same platform. However, one of the cases is particularly suitable to answer our research question, because it uses the platform in a way other than intended. The case involves a web-based multiple-project platform (eLaborate). We examine the use of this platform by one specific citizen science project (Gouda on Paper) in a different way than envisioned by its designers.

4.3.1 Research setting

In recent years, humanities researchers and many cultural heritage organizations, such as libraries and archives, have increasingly taken advantage of new Internet-based

technologies. They have initiated projects in which distributed amateur or non-professional citizens are invited to volunteer their time and knowledge to support scholarly editing by transcribing literary and historically valuable manuscripts via the Internet. Scholarly editions are texts about other textual work, which involve the accurate transcription of handwritten textual materials, their annotation or commenting, and their correction (Suarez & Woudhuysen, 2010, p. 1285), to make them accessible to other scholars for research purposes and readable for the wider public. The task of transcribing literary and historical textual materials is an important part of scholarly editing. Our case study concerns a citizen science project in the field of humanities, 'Gouda on Paper', where manuscripts are transcribed and translated (modernized) by citizen volunteers using a web-based multiple-project transcription platform (eLaborate).

Web-based multi-project platforms offer the possibility of standardizing project-independent actions, such as creating participant accounts, posting and updating project information, and ensuring browser compatibility (Prestopnik & Crowston, 2012). These web-based platforms support the digital transcription of manuscripts in citizen science projects by facilitating the division and online distribution of scanned pages among participants, and by integrating their corresponding transcriptions into the same environment.

4.3.2 Data collection

Data were collected from March 2013 to December 2015, as part of a wider research study on citizen science. For the study of 'Gouda on Paper', we gathered and analysed data from over 5 hours of semi-structured interviews, 1 hour of informal conversations, about 28 hours of observation, 41 project documents (including project manuals, minutes of meetings and news items), screenshots and documents about the online technological artefact (see Table 4.1).

The technological artefact 'eLaborate' was developed in several phases (see Figure 4.4). It was introduced into the project 'Gouda on Paper' in 2012, and the data for our study were collected in the period 2013-2015. Because the studied project had already begun when we started collecting data, this might have limited our study. However, the multiple sources of data and our iterative analysis and discussion with project participants have provided us with substantial information to counteract this limitation.

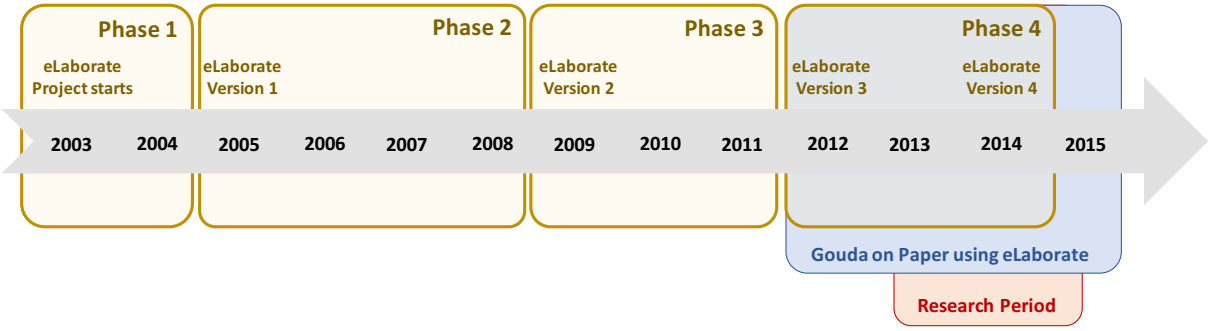


Figure 4. 4. Timeline of eLaborate's development, adoption, and research period.

Interviews: To understand how and why the web-based platform under examination (eLaborate) was created and modified over time, we conducted semi-structured interviews with people involved in its development. To find out how this technological artefact was used by the 'Gouda on Paper' project and to learn about the project's characteristics, we also held semi-structured interviews with project members. When discussing this technological artefact with project leaders and citizen participants, we asked questions such as: *Why did you find* [technology] *so useful for your project? Why did you use it instead of what you have used before?* Interviews lasted for one hour on average, and were transcribed verbatim. In addition to formal recorded interviews, the first author had informal conversations with project participants via telephone and Skype, of which notes were taken.

Observations: We observed 15 meetings of the 'Gouda on Paper' project, including work groups and technology training sessions. Though the first author took a non-participant role, she asked questions and had informal conversations with participants during the observation sessions. Notes were taken, and in 2 instances conversations were recorded. Through these observations, we were able to see how project participants interacted with each other and with the technology, and learned first-hand how this specific piece of technology worked in practice. The first author was also granted access to the technological artefact, which allowed her to examine its features and to compare its usage in different projects.

Documents: We collected 42 documents related to the citizen science project and 6 documents about the development of the web-based platform 'eLaborate'. The project-related documents included news articles, project newsletters, minutes of meetings, presentations, and various versions of the manual that guided the use of the technology and the standardization of contributions. Project newsletters and news articles were either gathered from the internet or provided by the project leader, as were manuals and other documents.

Images: Given our focus on affordances, we needed a way to bring technology's materiality into our analysis, other than interviewees' statements and descriptions of it. Because the first author had access to this online technological artefact, she collected images of its features. Images were also gathered from documents and screenshots of the different versions of the artefact. This allowed us to include technology's materiality in our analysis.

Table 4. 1. Data sources

Source	Number	Hours	No. of Pages
Interviews	**9**	**6**	**100**
Informal	4	1	7
Formal (recorded)	5	5	93
Observations	**15**	**28**	**91**
Without interview	13	26	49
With interview (recorded)	2	2	42
Documents	**42**		**281**
Project manual (versions)	12		137
Minutes of meetings (incl. agenda)	7		19
Open call (news articles)	4	-	4
Other documents (incl. university project)	15		100
Website (incl. project news)	4		22
Technology documents	**6**		**42**
Articles	1	-	17
Online sources	5		25
Images of technological artefact	**28**		**28**
Version 2	13	-	13
Version 3	3		3
Version 4	12		12

4.3.3 Data analysis

Collected data were stored, structured and coded using the qualitative analysis tool ATLAS.ti. As part of a larger research study on citizen science, we went through several rounds of open coding. After comparing multiple cases (Corbin & Strauss, 1990), we selected 'Gouda on Paper' as a typical case (Gerring, 2007) where technology is used differently than intended.

We focused our analysis on this case and included the information gathered about the technological artefact and its development. In a new round of coding, we identified designed, perceived and actualized affordances, and the organizational characteristics of 'Gouda on Paper'. We identified designed affordances mainly in documents about the origins and development of the technological artefact, but also in interviews with developers and early users. We coded statements explaining what kind of technology eLaborate was, or sentences referring to actions that eLaborate enabled its potential users to perform. To a lesser extent, statements made in documents and interviews with 'Gouda on Paper' participants were also coded as designed affordances if they referred to this technological artefact independent of its use in their project.

Perceived affordances were identified in the documents and interviews from the 'Gouda on Paper' project, and also in the documents and interview with the organization from which they learned about the technological artefact. Finally, coding actualized affordances involved identifying the actual actions enabled by eLaborate; in other words, its actual use.

Actualized affordances and experienced constraints were mainly found in observations and interviews with participants in the 'Gouda on Paper' project.

To support the reflexive analysis of the data (Srivastava & Hopwood, 2009), we wrote a description of the case. This description was revised and enriched with quotes to support the reliability of our case study and to show how we interpreted the data. Finally, we shared the case study findings with our informants to validate that our interpretations were correct.

In the following pages, we describe the development of eLaborate and give an account of its adoption and use in the citizen science project 'Gouda on Paper'. We explain how the project started, the tasks of its members, the reasons for their practices and goals of their actions, how they interacted with the technological artefact and the issues they faced. The story of the project is narrated with a focus on the affordances recognized by project members and on the resulting use of the web-based platform (eLaborate).

4.4 Findings

4.4.1 Technology and its designed affordances

'eLaborate' is a web-based platform or work environment, developed by the Dutch research institute for history and culture, Huygens ING, to support the production of digital scholarly text editions (Beaulieu, van Dalen-Oskam & van Zundert, 2013). The development of eLaborate started in 2003, its first version was released in 2005 and it was progressively improved through several stages. At each stage, improvements were made based on: 1) the input of its first test users (Beaulieu et al., 2013); 2) the feedback of regular users in the context of their projects; and 3) the rapid technological changes in that period. In 2009, a second version was issued, but eLaborate continued to be enhanced following new technological developments and the feedback from its users, resulting in version three, released in 2012. Version four was made available in 2014, with the announcement that it would be the last one developed by the Huygens Institute. Its code is now available as open source through Github (http://elaborate.huygens.knaw.nl) for anyone interested in the further development of this tool.

In general, all the versions of eLaborate that we observed include the following main features (see Figure 4.5): upload and download of files; entries, which include one or more pages of the manuscript in a 3-split screen format, with the scan of the pages, transcription and annotation (eLaborate 2) or preview areas (eLaborate 3 and 4); zooming in and out of facsimiles; customizable metadata fields; customizable annotations; searchability of the full text; and management of access rights (not visible in the figure).

eLaborate was specially designed for the digital transcription, annotation and edition of manuscripts: *"What makes eLaborate special is that it allows philologists to edit texts in an easy and recognizable way."* Hence, its main affordance is the online edition and annotation of texts. In addition, eLaborate was designed to afford collaboration among distributed humanities scholars. That is, eLaborate was intended to support the transcription, annotation

and final editing of textual materials, to be performed by multiple distributed scholars. This is explained in an online document about the evolution of this artefact: *"eLaborate had to offer an online platform for collaboration in the humanities. The idea behind this was, and it still is, that geographical limitations should not stand in the way of fruitful scholarly collaboration..."*.

This quote illustrates the potential for collaboration that eLaborate's designers had in mind for this technological artefact. It also points to a nested affordance without which collaboration would not be possible, namely eLaborate was meant to afford distributed work. Other nested affordances that made collaboration possible were the potential to integrate materials and to allocate tasks among different people. That is, eLaborate was devised to allow the online integration of scanned manuscripts, transcriptions and annotations in one single platform. And by making these materials structured and visible in the form of 'entries', eLaborate also afforded the allocation of tasks. This allocation could be done either by a project leader assigning parts of the document to specific people, or by individuals selecting which parts they wanted to work on.

It is important to note that originally eLaborate was created for humanities researchers as target users and, as such, the expected way of working (i.e. norms and division of labour) entailed the contribution of transcriptions on an individual basis: *"our users contribute to a common textual text, but do so by working in parallel*" (Beaulieu et al., 2013, p. 122).

Additionally, this artefact not only resulted from the combination of specialized research practices and Web 2.0-based functionality (Beaulieu et al., 2013), but was also improved and further developed in several stages. At the beginning, designers took a user-centred approach and involved a group of users to provide feedback on the platform as it was being developed (Beaulieau et al., 2013). In later phases, developers distinguished between the further development of the platform, its regular maintenance, and the list of smaller and faster improvements requested by users.

One example of the type of changes made between version 3 and version 4 was resolving issues of speed in loading materials. eLaborate's version 3 had a static structure of the entries, and users had to scroll up and down through the list of entries to find the ones that were assigned to them. In version 4, developers created what they called a 'facetted search', which allowed users to filter the entries based on metadata fields. This meant that in cases where a metadata field was added to specify the user name to which entry was assigned, the user would be able to filter the entries assigned to him/her. In a similar way, the user could filter entries on the basis of other criteria, such as the date of the manuscript or its author. This example shows how, over time, new affordances were designed into eLaborate; that is, the new version of eLaborate afforded clearer and more efficient access and searchability of the entries, resulting in improved allocation of tasks.

Table 4. 2. Designed Affordances

Designed Affordances	Interpretation	Illustrative Quote
Editing and annotating	Technology offers project participants the possibility to edit and annotate materials.	*"This is the online work-environment for textual editors and textual researchers that has been developed by Huygens ING."*
Collaboration:	Technology offers humanities researchers the possibility to collaborate in creating digital scholarly editions.	*"When eLaborate started in 2003, it was the objective of the project to create a collaboratory for humanities researchers."*
• Distributed work	Technology offers project participants the possibility to perform tasks from home.	*"The institute uses eLaborate for different edition projects where groups of researchers in different locations, through the Internet, work together in the creation of digital editions."*
• Integration of materials	Technology offers project participants the possibility to integrate scans, transcriptions and translations into one online platform.	*"eLaborate allowed to put and create materials online in a graphical interface (i.e. the work environment)."*
• Allocation of tasks	Technology offers project participants the possibility to view and choose which tasks to perform.	*"If you work with a group of people in the same project, as a project leader, you can use the 'volunteer' field to assign entries to a volunteer for editing. The volunteer can use this to filter the entries that have been assigned to him."*

In the following section, we describe the case of 'Gouda on Paper', a citizen science project that adopted eLaborate in 2012. We first introduce the project and describe its way of working, then we explain how the project leaders learned about and adopted eLaborate, and conclude by explaining how this technological artefact is being used at the time of writing this paper.

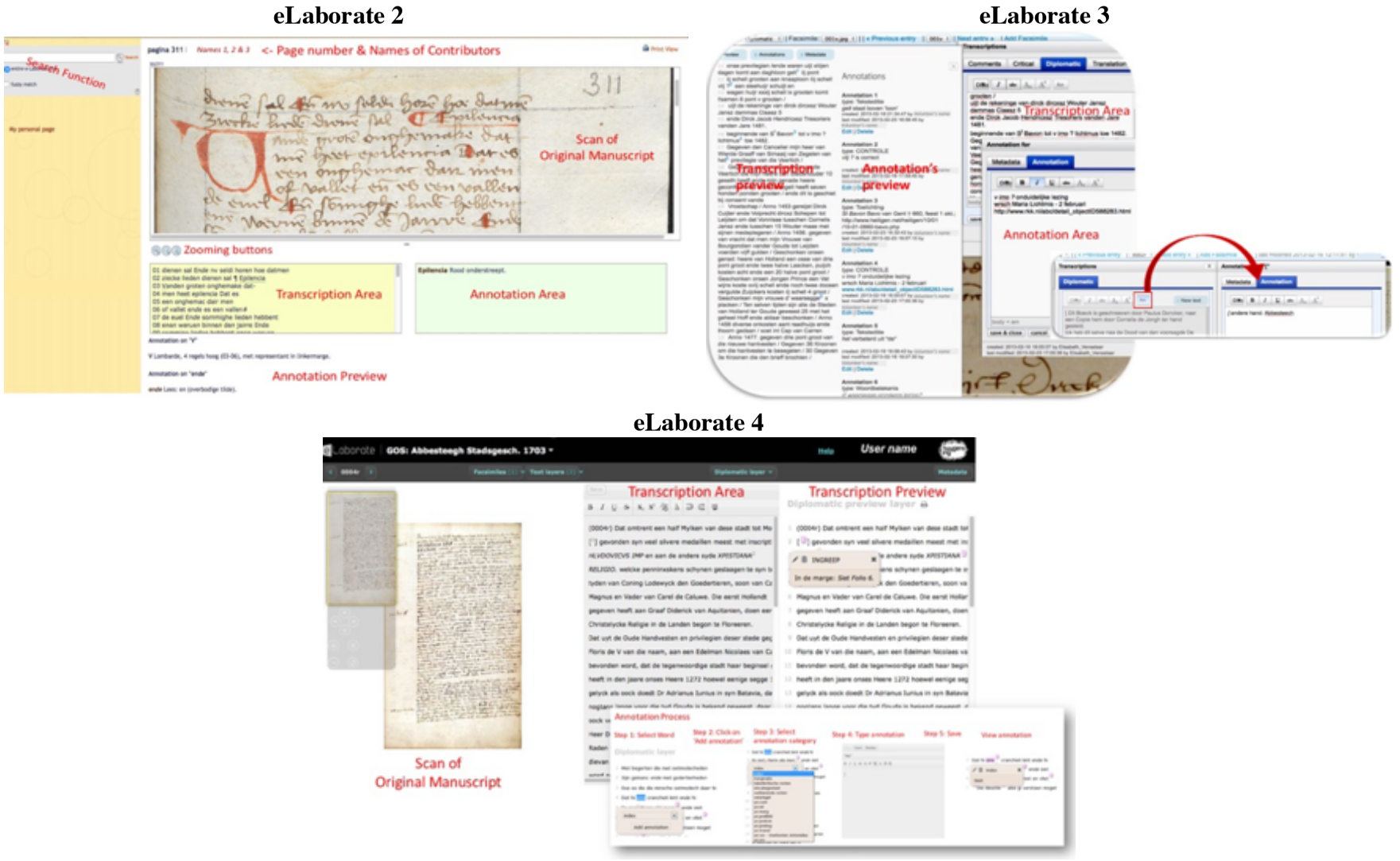


Figure 4. 5. Web-based transcription environment 'eLaborate', versions 2, 3 and 4

4.4.2 The citizen science project: 'Gouda on Paper'

The 'Gouda on Paper' project started as a volunteering initiative in collaboration with the Gouda regional archive. The aim of the project was to transcribe and translate important manuscripts (written before 1800) that were stored in the archive, make them accessible online and increase the public's awareness and knowledge of these writings. The project leader was an expert volunteer with an educational background in language, specialized in old French and medieval Latin, and about 10 years of experience in coordinating volunteers. 'Gouda on Paper' started as a result of the convergence of several factors: first, the project leader participated in a palaeography course organized by the regional archive; second, the regional archive wanted to make its archive materials more accessible; and third, a historical association was interested in publishing specific archive materials online. The project leader and an expert archivist decided to seek volunteers to contribute to the digital transcription and translation of manuscripts. In November 2011, they issued an open call in the local and regional media asking for volunteers. About 60 people responded to the call and attended the first project meeting. In view of the unexpectedly large number of participants, the project leader decided to set up work groups according to their time availability, and assign different sections of the manuscripts to each group.

Participants were given a form on which to enter their contact details, their educational and professional background, specific knowledge or skills, availability during the week and preference for meeting in the morning, afternoon or evening. Based on this information, groups were formed and the further organization of each group was left to the members to decide.

In general, the groups were organized as follows: they decided on a date, time and location to meet, which was usually the home of one of the members; they started the meeting with tea or coffee and talked about personal things, like holidays, children, dating, and so forth; then they moved on to the task at hand, which usually took about two hours; and at the end they agreed on a new meeting date, time and location. These meetings were possible because project participants lived either in the same city (i.e. Gouda) or in other cities and villages in the same region, which made face-to-face group meetings relatively easy to schedule. The tasks performed by these groups were mainly the transcription or translation of manuscripts. The scans of the original manuscripts were stored in the project Dropbox, where they could be accessed by all participants. Group members all went through the same section of the original text individually at home and made their own transcription or translation. Then, during the group meeting, they discussed the section with the other participants and came up with one agreed version of the transcription or translation. One of the group members was responsible for typing it up in Word and uploading it to the Dropbox. Communication with the project leader and between the group members took place mainly via e-mail.

The groups of volunteers were therefore responsible for transcribing and translating their assigned sections of manuscripts. Once the volunteers felt they had finished these texts to

the best of their ability, they communicated this to the project leader. Then the project leader and the expert archivist would review the volunteers' contributions and give them feedback.

At the beginning of the project, in order to manage the quality control workflow, the project leader asked volunteers not to send their transcriptions after every meeting, but to finish a larger portion of the assigned tasks before sending them for revision. However, this resulted in a considerable backlog of revision work. In addition, the project had few rules and no standard had been agreed about how volunteers should present the transcriptions. All the groups therefore delivered their Word documents with different formatting, which made the revision task difficult and time-consuming. For these reasons, the project leader decided to look for a way to deal with this emerging situation.

The project leader searched the Internet for examples of transcription rules that could help volunteers in transcribing, and at the same time provide standardization to facilitate the revision process. She came across a similar citizen science project that had been initiated by a Dutch university. In April 2012, the project leader and the archivist visited the project group at the university, with the aim of learning how they worked and especially how they made sure that volunteers remained interested in the project for a longer period of time. They learned about that project, and about the web-based platform (eLaborate 2) that they used to integrate the multiple contributions of project participants.

4.4.3 Perceived affordances

The 'Gouda on Paper' project leader and the archivist came out of that meeting perceiving new possibilities for their project. As a result of their visit to the university, they believed that eLaborate might allow them to improve the coordination of their project, standardize participants' input, support the communication between them, and integrate the transcription, translation and original manuscript in a single work environment (see Table 4.3). The perception of these affordances was evident in the request made by 'Gouda on Paper' to access eLaborate.

In a letter to the institute responsible for developing eLaborate, 'Gouda on Paper' referred to the possibility of coordinating tasks: *"Given the intensive coaching that a volunteering organization like ours needs, we would very much appreciate it if we could make use of eLaborate, just because of the possibilities it offers to take over some part of the coordination and workshop work."* They also mentioned the possibility of standardizing inputs: *"Because we are transcribing several texts, we can guarantee the standardization of the way of working through eLaborate"*; the possibility of using eLaborate as a means of communication: *"not only can the members of the group communicate with each other, but the groups can also communicate with each other via the logbook in eLaborate"*; and the possibility of integrating the different elements of their project: *"The presentation of eLaborate fits very well with the ideas that we have about it. We have worked out these ideas, in terms of content and realization, on our website."*

These perceived action possibilities (i.e. affordances) offered by eLaborate, were based on what they had seen and heard during their meeting with the project leader of the university

project. At that point, they had no first-hand experience of how to use the platform. Hence, they based their perception on the experience of others, that is, on 'vicarious experience'. They learned from the experience of the university project, where citizen contributions were made individually, and communication was facilitated by the use of html boxes (called 'logbooks') in eLaborate version 2.

Despite the perception of affordances based on vicarious experience, the project leader and archivist representing 'Gouda on Paper' acknowledged one potential challenge for implementing eLaborate in their project. They recognized that eLaborate had mainly been used to integrate individual contributions, while their project was characterized by group work. However, the potential challenge did not appear to outweigh the benefits of perceived possibilities for improved coordination, standardization, communication and integration.

One explanation, especially for the perceived standardization, integration and coordination of contributions, might lie in the motivation of the project's core activity: 'making historical manuscripts widely accessible'. For that purpose, contributions needed to be of good quality, and distributed pages needed to be re-integrated back into their corresponding books. Project leaders wanted to find a way to manage the integration and quality of transcriptions (goal). By searching the Internet (action) for examples of transcription rules (standardization), they came across the university project and thus found out about eLaborate.

Table 4. 3. Perceived Affordances

Perceived Affordances	**Interpretation**	**Illustrative Quote**
Editing and annotating	Technology offers project participants the possibility to edit and annotate materials.	*"They told us about the program that they use from the Huygens Institute: eLaborate. With it, you can work on the transcription, translation and annotation of manuscripts."*
Integration of materials	Technology offers the possibility to integrate scans, transcriptions and translations into one online platform.	*"The advantage of eLaborate is, of course, the three screens next to each other. Thus, you can see the photo of the original text, you can see the transcription and the translation."*
Coordination:	Technology offers the possibility to coordinate the tasks of project participants and monitor progress.	*"…the possibility to use eLaborate, would relieve us of some of the coordination and workshops."*
• Communication	Technology offers project participants the possibility to communicate with each other.	*"Participants can also react online to each other's work"*
• Visibility	Technology offers project participants the possibility to view each other's contributions.	*"… as soon as everything is in the computer next week, then everyone will work with eLaborate and every week [project leaders] will look… because now we can see what everyone has done."*
• Integration of contributions:	Technology offers the possibility to integrate the transcriptions and annotations contributed by project participants.	*"… the great advantage of using eLaborate is that it integrates the work of several people, which is much easier than working with several Word documents and trying to put them all together."*
o Standardization	Technology offers the possibility to standardize the look and metadata of participants' contributions.	*"… it helps enormously with uniformity! Because it's there, it is in eLaborate. eLaborate is almost like a bible, because it is with the same rules that we have come up with ... but if it is there than it should be good."*
Public accessibility	Technology offers the possibility to make transcriptions accessible to other researchers or the general public.	*"Transcribed texts are put on the Internet. They are then available for scientists who wish to read and used them for research."*

4.4.4 Actualized (and non-actualized) affordances

Given the possibilities offered by eLaborate, the project leader and archivist put everything in place to adopt this web-based platform, including an official agreement with the Institute and development of manuals and training sessions for the volunteers. The first training session was for representatives (i.e. coordinators) of each group. Each participant was given his/her own personal login code and, the session was followed by an experimentation period. During that period, volunteers experienced working with eLaborate and they realized that it did not fit in with their existing collaborative practice.

Before eLaborate was introduced into the project, the norm was collaborative group work. Volunteers had already established their work practices. As explained above, they worked in groups and performed transcriptions and translations in a collaborative manner. That is, several individuals worked simultaneously on the same piece of text and, then they held work group meetings, in which they compared their individual transcriptions and produced a final agreed version of the transcription (or translation). To this end, they used multiple mediating tools: e-mail, to communicate with each other; Dropbox, to store and share files; and text processing software, such as free specialized transcription software[11] used by a few people, or Microsoft Word, which was used by most participants.

Though eLaborate allowed multiple people to work on different sections of a manuscript, it did not offer a feature to track changes or compare versions of the transcribed sections, thus hindering the collaborative transcription of the same pages. *"…we came to the conclusion quite soon that… maybe it is not such a good idea that we all work in eLaborate directly, and this is because we soon saw that eLaborate only has one version and the last person to save his/her work, that's the only version that's left."* This was confirmed during our observations, as we saw how the groups worked out their transcriptions and translations in Word. When asked why they did not write them in eLaborate instead, they explained that the artefact did not allow them all to work on the same text, because it only kept one version: the last one.

Changes in the division of labour reinforced the volunteers' belief about eLaborate's constraints to their collaborative work. As the number of transcriptions increased, the task of reviewing became too much for the project leader and the archivist alone. Moreover, even though there was no deadline, the project leader urged participants to finish their tasks and not start new ones, so that the transcriptions could be published as soon as possible. Finishing tasks also meant assuring the quality of the final transcriptions and translations. They therefore set up reviewing teams, consisting mainly of expert volunteers. They established one team responsible for revising the transcriptions, one team for checking the translations into modern Dutch, and one to review and edit the modern Dutch text. However, these teams did not use eLaborate to review the texts, and used Word instead. In their own words: *"If you make changes in there than you lose the previous one, gone! You cannot see what you had before. And that is not the idea, because it has to be reviewed."* Basically, because the

[11] http://www.jacobboerema.nl/en/Freeware.htm

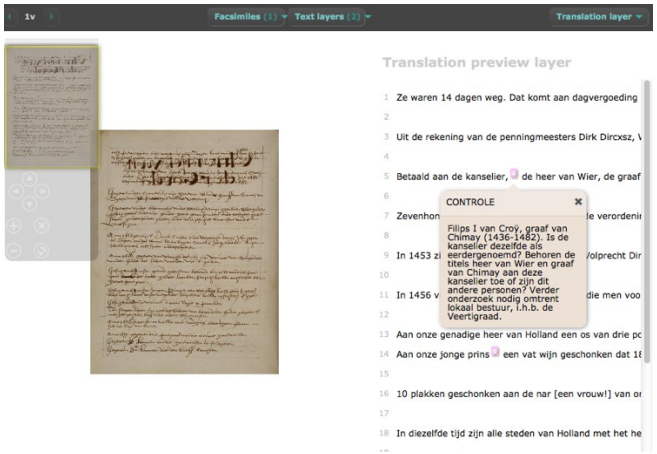
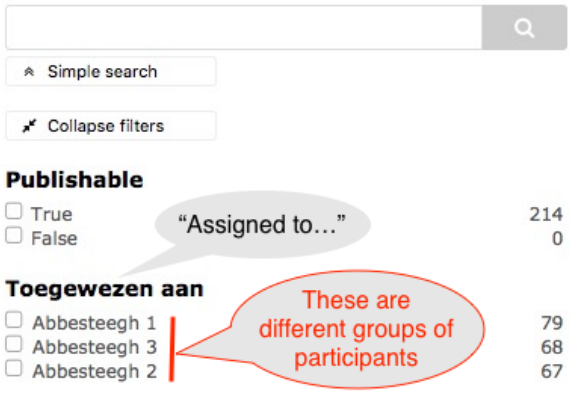
work of each team was interdependent and they were not looking at the same aspects of the text, they needed to be able to explain their decision to choose a certain translation or include suggestions for the next team. *"If [Expert Volunteer] wants to tell us, give us comments on a certain text, he should be able to do so, and that is not possible in eLaborate."*

The actualization of affordances was based not only on the existing way of working, but also on other technological artefacts used in the project, in particular Word. Volunteers emphasized the wider options offered by Word for processing text, the possibility of tracking changes and the fact that most people had already learned to work with that program. *"In practice, we get a version in Word from [the other team]…and they make suggestions for improvement, so that we can see what they have done. And this can only be done in a Word document. In eLaborate you only have one version."* This quote also illustrates the fact that Word was not only used to track changes, but also to communicate about the text.

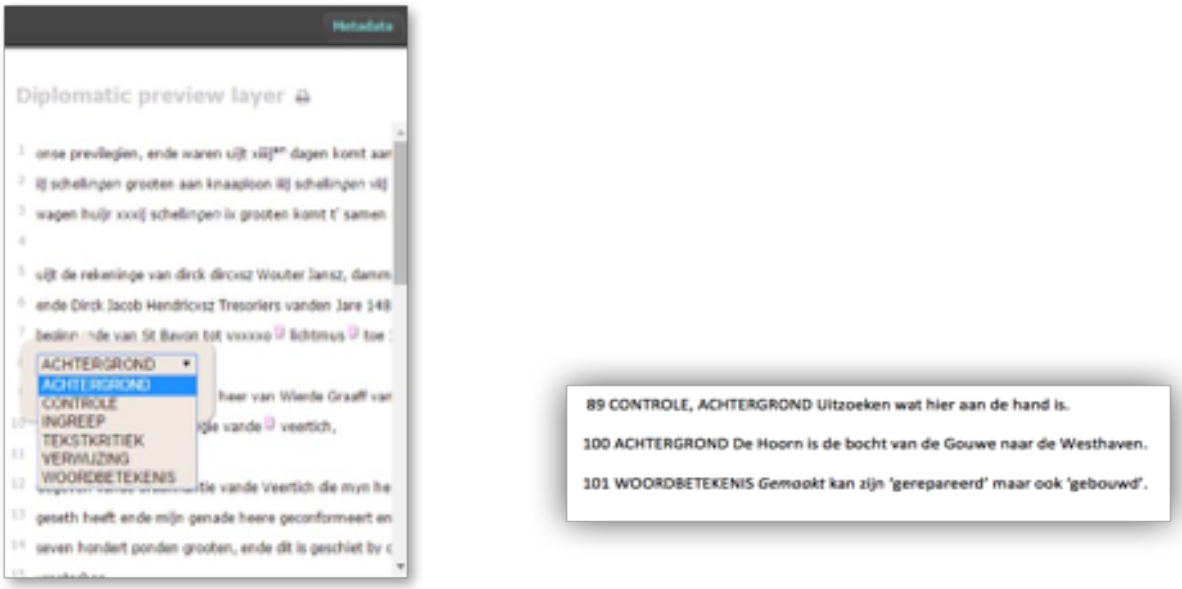
Another factor that influenced the actualization of affordances was that eLaborate changed between the time when 'Gouda on Paper' first learned about it (version 2) and when they started using it (version 3). In the second version, eLaborate included html-based text boxes in the main page of each entry. Early users of eLaborate, such as the university project, used these text boxes as a means of communication between participants and therefore called them 'logbooks'. These logbooks were also the reason for the perceived communication affordance expressed by 'Gouda on Paper' project leaders. However, these html-based text boxes (i.e. logbooks) were eliminated in the third version of eLaborate, which was the version used by 'Gouda on Paper'. Their elimination meant that the communication affordance could not be actualized in eLaborate.

Despite the constraints that eLaborate presented for the collaborative transcription among volunteers of 'Gouda on Paper', they continued to use the platform, yet in a way other than intended by its designers or even by the project leaders. That is, volunteers did not use eLaborate as a work environment for their transcriptions. Instead, they used it as a repository, where they uploaded their group's final transcription and translation texts. *"…as I said, the way we work…eLaborate knows only one text, thus if we work with six people there is only the last version, you cannot compare. That is why we, as a group, work outside of eLaborate by first coming to a conclusion with the text 'that's it' and then you can put it in eLaborate."* They copied their transcriptions and translations from the text processing software into the platform. *"And once we have completely finished it, then we copy it in blocks into eLaborate, so that we do not make a mess in eLaborate."*

Table 4. 4. Actualized Affordances

Actualized Affordances	**Interpretation**	**Illustrative Quote / Image**
Integration of materials	Project participants integrate scans, transcriptions and translations into the same online platform.	*"Anyway, it is finally presented: photo, transcription, translation. These ones are optional, you can hide them, but the photo always comes on the left."* 
Integration of contributions	Project participants integrate their contributions into the same online platform.	

By giving eLaborate a different role in their activity, volunteers only had to slightly change their way of working. They adjusted the team's division of labour by having one person in the group uploading the transcriptions in eLaborate. Other than that, volunteers continued working as they were used to. At the same time, they actualized the standardization that the project leader and archivist sought for the project. eLaborate was originally seen as a potentially useful tool for the project's reviewing activity, because it afforded the creation of rules and the standardization of the transcription format, which could support the quality control workflow. "*… someone does it like this, the other one like that, and the other so, the point is that now that we are going to work with eLaborate, we finally have rules that hold for everyone and give us a foundation […] Yes, we are now forced to go along the same vein*."



a **b**

Figure 4. 6. Drop-down menu with annotation categories / Annotations in Word

To fill in transcriptions and translations in eLaborate, volunteers needed to keep to a certain format and rules. They used the manual and the standardized rules that were developed to work with eLaborate and applied them in Word. For instance, one of the features of eLaborate was the possibility of creating annotation categories. Once these were defined, users could select the standardized annotation categories from a drop-down menu (see Figure 4.6a). The meanings of these categories and when to use them were specified in the eLaborate manual. Following the rules of the manual, volunteers used the same annotation categories in their Word documents (see Figure 4.6b).

Therefore the standardization possibility offered by eLaborate was actualized, but in a different way. Standardization was not achieved through the use of eLaborate itself, but instead by applying its rules to another technological artefact (i.e. Word).

Table 4. 5. Different designed, perceived and actualized affordances

	Designed Affordances	**Perceived Affordances**	**Actualized Affordances**	
Technology	**eLaborate 2**	**eLaborate 3**	**eLaborate 3 & 4**	**Word**
Affordances	• Editing and annotating	• Editing and annotating		
	• Collaboration ○ Distributed work ○ Integration of materials ○ Allocation of tasks	○ Allocation of tasks ▪ Visibility	○ Integration of materials	
		• Coordination ○ Communication ○ Integration of contributions ▪ Standardization ○ Public accessibility	○ Integration of contributions	○ Communication ○ Standardization
Actors	**Designers**	**Managers**	**Users**	
Activity	**Designing technology**	**Solution searching**	**Performing task (transcribing and translating)**	

4.5 Discussion and conclusion

In this chapter, we set out to understand why technology is used in ways other than intended. To this end, we propose an analytical framework that distinguishes between designed, perceived and actualized affordances. At the same time, we situate affordances in the context or activity systems of social practices. The application of our framework in an empirical case demonstrates that it is analytically useful to identify and compare designed, perceived and actualized affordances in context. We conclude that technology is used in ways other than intended because it gives rise to different types of affordances when people with distinct roles and in diverse activities interact with it (see Figure 4.7). Yet 'all roads lead to Rome', and using technology in unintended ways can have the purpose of achieving the same intended objectives; in this case, high-quality citizen science outcomes.

We assume that the intended use of technology refers to designed affordances. These affordances emerge in the relationship between technology developers and a technological artefact as part of the activity of developing technology. Technological artefacts are the objects that drive the activity of these developers (Kaptelinin & Nardi, 2006). Designed affordances are the potential for action that developers envision and build into technological artefacts. Designed affordances emerge in the interaction between developers and technology as the epistemic object of the technology-developing activity. Designed affordances are therefore influenced by the tools, rules, community of stakeholders and division of labour of that activity.

Perceived affordances emerge within different activity systems than the activity of technology developers. Managers, or people in specific leadership positions, frequently engage in the activity of searching for solutions to organizational problems. As part of this activity, they sometimes come across technological artefacts that, from their perspective, might afford the solution to their organizational problems. Hence, affordances are often first perceived by these managers within the context of their solution-searching activity. The activity, characteristics and goals of these managers, as well as the type of experience they have with the artefact, will influence the affordances they perceive.

Once a technological artefact is introduced into an existing activity, affordances will be perceived and actualized by those who are supposed to use the technological artefact. The activity of technology users generally differs from that of the managers who decide about technology adoption. It is within the activity of these potential users that affordances are actualized or not. The activity, characteristics and goals of these users, as well as their experience with the technological artefact, will influence the affordances they actualize.

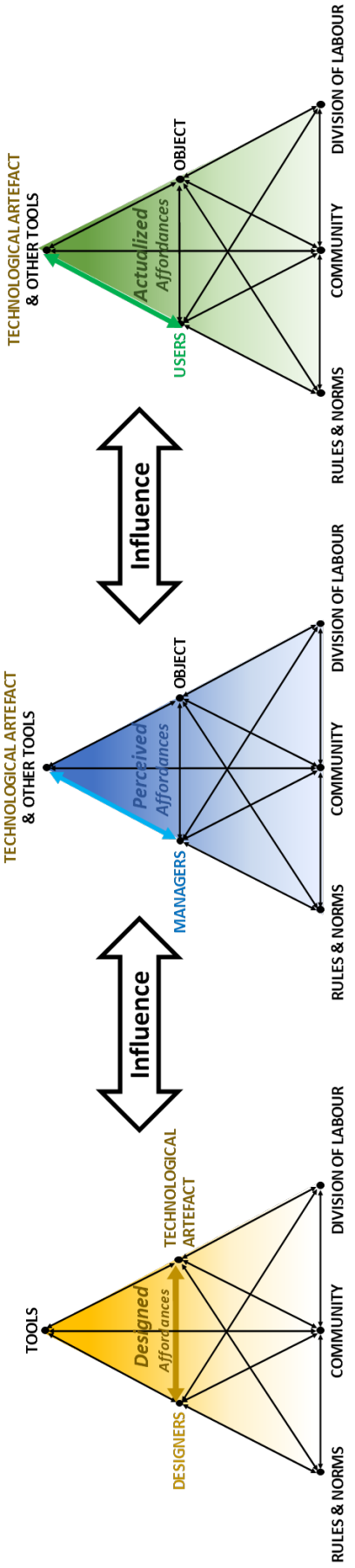


Figure 4. 7. Relation between designed, perceived and actualized affordances.

The distinction between designed, perceived and actualized affordances relates to the *'duality of technology'* (Orlikowski, 1992), but takes it one step further. That is, technology is created and affordances designed into it as part of the human activity of technology development. However, technology also mediates the activities of managers or decision-makers, and end users (Engeström, 1990), who have different work contexts, compared with each other and with developers. Therefore, by considering the time-space separation (Orlikowski, 1992) between development, adoption and use, we can distinguish different types of affordances and explain why technology is often used differently than intended. Moreover, the time and space gap between development and use allows technological changes to take place. Technological changes, in turn, influence the perception and actualization of affordances. This is especially the case with digital technologies, because they are incomplete or more frequently adapted to the changing needs of their users (Garud, Jain & Tuertscher, 2008).

In the studied case, we wanted to know why 'Gouda on Paper' used eLaborate in a way other than intended by its developers. eLaborate was designed to afford collaboration among humanities researchers in the editing and annotation of digitally transcribed texts. When project leaders from 'Gouda on Paper' were searching for a solution to their project's standardization issues, they came across eLaborate. Within their activity and in their role as project leaders, they perceived a set of coordination-related affordances. Since they had not experienced eLaborate before, their perceived affordances were based on 'vicarious experience'. As a result, some perceived affordances corresponded with designed affordances (i.e. editing and annotating, and integrating materials), while others emerged from other people's experiences with eLaborate (i.e. communication). However, not all the perceived affordances were actualized. First, the platform did not allow the tracking of changes made to transcriptions or translations. This clashed with the group work, which required comparison and merging of multiple versions of the same text. Therefore, not all tasks could be performed in parallel and there was a time lag in the integration of contributions. Second, eLaborate was compared against Word in terms of their affordances. While eLaborate afforded standardization, integration of inputs and a sophisticated annotation system, Word was seen as a familiar and flexible text processing tool, which allowed textual changes to be tracked and shared with other participants via e-mail. eLaborate therefore ended up being used as a repository instead of an online work environment. And third, eLaborate is an incomplete digital technology (Garud et al., 2008), which changed over time, not only as a result of rapid technological advances but also by integrating the input of test (Beaulieu et al., 2013) and regular users.

4.5.1 Theoretical implications

The affordances framework proposed in this chapter and the findings of our case study have two implications for the theory of affordances. First, they demonstrate that it is possible to distinguish between designed, perceived and actualized affordances. And second, they show that technology is more likely to be used differently than intended when these different types of affordances emerge within different activity systems.

Technology use is the result of a dynamic process that goes from the design, to the perception and to the actualization of affordances. In this process, designed affordances are the starting point and represent the intended use of technology as envisioned by technology developers. When people become aware of the potential actions that technology allows them to perform in the context of a specific activity, we talk about perceived affordances. As soon as people start using the technology to perform those possible actions, we can say that affordances have been actualized.

Designed, perceived and actualized affordances emerge within different activities. Designed affordances are part of the activity of developing technology and arise in the interaction between technology developers and technology, as the activity's epistemic object (Nicolini, Mengis & Swan, 2012). Though it is typically assumed that Norman's perspective on affordances locates them in the object (Faraj & Azad, 2012), an activity theory approach makes their relational character more obvious. From an activity theory perspective, designed affordances emerge in the relationship between the technology developers and the object that is being created in the activity of technology development. According to activity theory, the object of the activity is emergent (Nicolini et al., 2012) or, in other words, its design is incomplete (Garud et al., 2008). Digital artefacts are incomplete and, as such, their development is mediated by new emerging technologies and the input and/or feedback of the community of stakeholders. Consequently, designed affordances can vary as the needs of technology users change over time.

Perceived affordances emerge within problem-solving activities, usually performed by people in managing or decision-making positions. Managers rely on their knowledge and experience for local search, and on their ability to recognize and evaluate potential solutions through distant search (Afuah & Tucci, 2012). Either way, this search activity is about gaining experience or learning about the technological artefact that might solve an organizational problem. That is, perception involves learning what is possible (Bærentsen & Trettvik, 2002; Hutchby, 2001).

To perceive a potential action, one needs to examine or interact with the artefact to learn about the relative fit between one's own characteristics and abilities and the artefact's materiality (Bærentsen & Trettvik, 2002). Learning can take place through either direct or vicarious experience (Argote, 2013; Huber, 1991). Learning through direct experience involves interacting with the technology and comparing it with other technologies. Existing mediating tools influence how a new technological artefact is perceived by users (Leonardi, 2011, p. 163; Fayard & Weeks, 2014, p. 243), because users compare the affordances of these artefacts in terms of their efficiency and effectiveness in supporting possible actions

(Leonardi, 2009). However, our study shows that, in the absence of direct experience, the perception of affordances is influenced by the experiences, ideas and opinions of actors with whom technology users interact (i.e. vicarious experience).

Affordances are actualized when people perform technology-mediated actions that are consistent with the activity's social and material structures. The affordances of a new technological artefact can either contradict or be congruent with the norms, community and division of labour that constitute organizational activities (Allen et al., 2013). For instance, work related norms refer to the patterns of behaviour or ways of working that are common or accepted within an organization (Fayard & Weeks, 2007); when perceived affordances are congruent with existing ways of working, they are likely to be actualized. Moreover, the array of technological artefacts already available in any established organizational activity system also influence actualization. Existing mediating tools influence how a new artefact is perceived (Leonardi, 2011, p. 163; Fayard & Weeks, 2014, p. 243) and, if it is compatible with those tools, its affordances will most likely be actualized by the users.

4.5.2 Limitations

Our study of affordances might have been limited by the fact that it was not our original intention to focus on this concept. We were studying the practices involved in citizen science projects in the humanities, including the use of technology, and during the analysis we observed different use of the same technological artefact among projects. To understand why and how this happened, we turned to the theory of affordances. However, we did not know what caused affordances to turn into specific actions. We needed a better understanding of the dynamics of affordances.

If we had planned to study technology affordances from the start, we would have looked for a project that was searching for a technological artefact to solve organizational issues. This would have given us more direct details about designed and perceived affordances. However, an affordances-only approach would not have provided us with the contextual particularities that the addition of activity theory has allowed us to learn.

Our framework not only proves that it is possible to distinguish between designed, perceived and actualized affordances, but also situates these affordances in the context of social practices or activity systems. The empirical application of this framework has helped us to explain why technology is sometimes used in ways other than intended.

4.5.3 Future research

This study has empirically shown that different technology use can be explained by differentiating between designed, perceived and actualized affordances and by considering the specific activity systems in which affordances emerge. However, our findings are based on just one case study and more research is needed to assess whether our framework and conclusions apply to other organizational settings. In addition, future research could investigate what happens if designed, perceived and actualized affordances emerge in different activity systems within the same organization. Future research efforts could also

examine the conditions under which perceived affordances are based on direct or vicarious experience.

Finally, more research is needed to understand the effect that technological improvements have on perceived and actualized affordances over time. In our case, we have seen that technological changes influence the actualization of affordances perceived in previous versions of an artefact. The continuous development of digital technologies and the ease with which they can be adapted to the needs of their users suggests that affordances might shift frequently. As organizations that develop technology increasingly release their products under open source licences, future research could examine how the changes made in those products bring about new affordances or more efficient and effective potential actions.

5
Discussion

I started this research journey with the aim of understanding how scientists' need for high-quality information is addressed in the organization of citizen science projects. In this chapter, I first answer the main research question, by reviewing the findings of my empirical research as presented in the preceding three chapters. Second, I discuss what these findings mean for current theory and suggest directions for future research. Third, I consider the practical implications that this study has for research organizations and scientists leading citizen science projects. Finally, I reflect on my own learning experience through the research process and on the topic of citizen science in general.

5.1 Summary of findings

Scientists' need for quality information from citizen science projects involves investing in knowledge management activities that support the learning process of citizen scientists, whose contributions are standardized and integrated through different digital technologies, sometimes used in unintended ways.

5.1.1 Quality is made through investments in knowledge

The aim of Chapter 2 was to understand how project leaders manage the quality of citizen science project outcomes. The challenge lies in ensuring quality in a context that involves knowledge work but where a knowledge gap exists between citizens and scientists, and where citizens' knowledge and/or skills are a priori unknown.

The empirical study presented in this dissertation has shown that, to deal with this challenge, project leaders invest their time and efforts in managing knowledge work. Project leaders not only simplify tasks, for example by splitting manuscripts into independent pages or sets of pages, but also perform and organize knowledge management activities to ensure quality. First, project leaders recruit knowledgeable individuals through open and targeted calls. By issuing open calls, project leaders rely on the self-selection mechanism inherent to volunteering-like phenomena, while those targeting specific groups of people evaluate citizens as knowledge sources. Second, project leaders, as experts in their own field, share their knowledge with citizens during meetings, training sessions and online interactions. They also codify their knowledge in manuals or guidelines. Third, by establishing workflows or organizing tasks, project leaders coordinate participants' work. The organization of tasks depends on the characteristics of each project, but when the number of citizen participants is small or they are geographically dispersed, tasks are typically performed individually. In projects with larger numbers of individuals, tasks are sometimes rotated among participants or discussed and revised in groups. Finally, in all projects, the quality of citizen contributions is assessed, and improved where necessary. In projects with small numbers of participants, the contributions are usually assessed by project leaders, while in projects with a larger group of participants, skilled volunteers are asked to perform this task.

Therefore the need for quality in citizen science results in project leaders investing time and effort in managing knowledge work, evaluating knowledge sources and knowledge-based contributions, and supporting citizens' knowledge acquisition and learning process in general. The different activities and combinations of activities used to manage and evaluate knowledge work mainly depend on the number of participants, which results from the approach taken to acquire knowledge, or in other words, to recruit citizen participants. Other factors that affect the types of knowledge management activities used are: the geographical distribution of participants, the characteristics of the tasks, the available technology, and the extent to which project leaders know about the participants' level of expertise.

5.1.2 Practice makes perfect

The purpose of Chapter 3 was to examine how project leaders' strive for quality affects the efforts and learning process of citizens contributing to citizen science projects. To that end, I introduced the concept of 'extra-organizational learning' and sought to understand how it takes place in practice. Extra-organizational learning refers to the process that characterizes learning in citizen science projects and in other situations where individuals who are external to the organization perform tasks that serve as input for the focal organization's activities. Extra-organizational learning mirrors the feedback learning or knowledge exploitation process of the 4I framework (Crossan et al., 1999; Zietsma et al., 2002), as knowledge that is institutionalized in organizational practices is shared with individuals who are external to the organization. In this dissertation, I have shown how knowledge that is institutionalized in scientific practices (for example, transcription conventions and text-encoding language) is shared with participants in a citizen science project.

Organizations support this extra-organizational learning process with guidelines and feedback. Guidelines and feedback are not only used to support learning in citizen science, but are also the means used by service companies to teach their customers how to perform certain tasks. Indeed, extra-organizational learning is often found in the service sector, where it is increasingly common to outsource simple tasks to customers. Service customers learn to perform specific tasks by following rules, such as garbage preparation rules issued by waste management companies (Turner & Rindova, 2012) or the 'Make It Your Drink' guide used by Starbucks to instruct customers about the company's preferred ordering steps (Frei, 2006). Just like citizen scientists receive feedback about their performance from the expert project leaders, service customers find out about their performance when the service is delivered without problems and on time. Whether in citizen science or in service companies, guidelines and feedback are used to increase skills but, at the same time, reduce potential skill variability among citizens or customers.

The empirical research on extra-organizational learning in the context of citizen science has also uncovered an essential condition for extra-organization learning to occur, namely participant retention. Citizens need to remain involved in a project for longer periods of time in order to learn by doing, receive feedback about their performance, and continue to perform and deliver higher quality over time. The retention of participants in a citizen science project is therefore a necessary condition for learning and for improving the quality of contributions.

5.1.3 Technology supports quality even when used in unintended ways

Chapter 4 focused on the use of technology in citizen science. Specifically, I sought to clarify why a web-based multi-project platform, meant to support quality by standardizing and integrating contributions, was used differently than intended by its designers. For that purpose, I turned to the theory of affordances.

Actualizing affordances means turning action possibilities into actual actions. In the case of technology affordances, actual actions refer to the factual use of the technology. Since it is generally accepted that technology is often used differently than intended, the focus of the chapter was to examine the events occurring between original intentions and final use. To achieve this, I have shown how the distinction between designed, perceived and actualized affordances can explain why technology is used in unintended ways. In the studied case, these different types of affordances emerge within different activity systems. Designed affordances emerge as part of the activity of technology development, perceived affordances arise within the problem-solving activities of project leaders, and affordances are actualized in the activity of citizen scientists as technology users.

Each of these types of affordances is influenced by different factors. Designed affordances emerge from the interaction between developers and technology itself, as the epistemic object of the technology-developing activity. As an emergent or epistemic object (Nicolini et al., 2012), digital technologies, such as the ones used in citizen science, are incomplete (Garud et al., 2008) and their affordances can change as technology in general evolves and user needs change over time. Perceived affordances are not only influenced by technology's materiality and the characteristics of potential users, but also by vicarious experience. When project leaders cannot directly experience or interact with technology, they rely on other people's accounts of their experiences. Similarly, the actualization of affordances depends not only on materiality and users' characteristics, but also on the norms, community, division of labour and other existing artefacts that make up the end users' activity.

Finally, the study shows that even when affordances are not actualized as expected, the resulting unintended use of the technology does in fact support the achievement of quality. Therefore the need for quality in citizen science means that the use of technology can take unanticipated turns without compromising the project's goal of scientific quality.

Table 5. 1. Summary of findings

Chapter	Research Question	Key Findings
2. Quality in the making: Managing knowledge in citizen science projects	How do citizen science project leaders ensure the quality of project outcomes?	Citizen science project leaders ensure the quality of project outcomes by investing their time and efforts in managing knowledge work performed by citizen participants. The approach taken to recruit citizens seems to be essential in deciding the combination of knowledge management activities that follow. Project leaders' choice of open and/or targeted calls, together with the proximity of participants, the available technology and task characteristics, influence how knowledge is shared, how tasks are organized and how citizens' contributions are evaluated. This knowledge management perspective on citizen science highlights the process of knowledge assessment. It shows that what the assessment really focuses on is: people, as sources of knowledge; and the outcomes of their knowledge work.
3. Extra-organizational learning: Learning beyond organizational boundaries	How does extra-organizational learning take place in practice?	The quality of citizen science project outcomes improves as citizens learn and provide higher-quality contributions over time. Taking an organizational learning perspective on citizen science shows that organizations can benefit from the learning process of individuals external to the organization. This process, which I call extra-organizational learning, is supported by organizations with guidelines and feedback. Guidelines and feedback are the means by which institutionalized knowledge is shared with those individuals. Moreover, in the case of citizen science, a necessary condition for extra-organizational learning to take place is the retention of citizen participants for longer periods of time.
4. The dynamics of affordances: Using an online citizen science platform	How does the distinction between designed, perceived and actualized affordances help to explain the use of technology in unintended ways?	In citizen science projects, technology is used to support quality by standardizing and integrating citizens' contributions, even when used in ways other than intended. A technology affordances approach helps to explain why technology is sometimes used in different ways. Adding activity theory into the analysis shows that technology is more likely to be used differently than intended when affordances are designed, perceived and actualized within different activity systems.
Managing Citizen Science in the Humanities: The challenge of ensuring quality	How is the need for quality addressed in the organization of citizen science projects?	High-quality information is essential for science. To ensure the quality of information resulting from citizen science, project leaders invest time and effort in supporting the learning process of citizens and managing the knowledge work performed by those citizens, even if this means using technology in unintended ways.

5.2 Theoretical implications and suggestions for future research

Focusing on the need to ensure the quality of information from citizen science projects draws attention to three topics: knowledge assessment, learning and retention, and the openness of projects.

5.2.1 Quality and knowledge assessment

This study contributes to the knowledge management field by emphasizing the importance of knowledge assessment, as a knowledge activity that has received relatively little attention in the literature. Explicit accounts of how knowledge is assessed are limited, and scattered across the broad management literature (Rasmussen & Haggerty, 2008; Geiger & Schreyögg, 2009, 2012). Through my research, I have identified two possible reasons for the scant attention given to knowledge assessment.

First, because knowledge is intangible (Spender, 1996) and it becomes apparent in human practices (Nicolini, 2011), it cannot be directly assessed. Therefore, if we are to speak about knowledge assessment, I suggest we refer more specifically to value judgments about the sources and outcomes of knowledge work. Sources of knowledge refer to objects, such as artefacts that we experience or documents that we read, and individuals with whom we interact or whose actions we observe (Haas & Hansen, 2007; Huber, 1991). The outcome of knowledge refers to any expression or representation of knowledge. Expressions of knowledge can be tangible, like a product or a document, or intangible, like a routine, a service or advice. When the outcome or expression of knowledge cannot be easily assessed in advance, people tend to evaluate the source of knowledge (Kane et al., 2005, p. 59).

Second, assessing knowledge is usually an ongoing activity embedded in the different processes of knowledge acquisition, sharing, creation and application (Rasmussen & Haggerty, 2008), which might explain why it is likely to be overlooked. I therefore propose that the study of knowledge assessment should focus on each of the knowledge management processes. For instance, in the process of knowledge sharing, before individuals accept new knowledge, they assess the sources and expressions of the knowledge that is being shared (Kane et al., 2005). Similarly, part of the knowledge creation process involves considering the legitimacy of expressions or outcomes of knowledge according to the practices and criteria that characterize different knowledge domains (Robertson et al., 2003).

In Chapter 2, I have shown that citizen science project leaders ensure quality by acquiring and sharing knowledge, organizing tasks and assessing citizens' contributions. In this process, knowledge assessment is clearly evident in the acquisition of knowledge (i.e. recruiting participants) and in the evaluation of citizens' contributions.

The acquisition of knowledge through recruiting can take place via open calls or by targeting specific groups of citizens. In the first case, knowledge assessment is entrusted to citizens themselves. That is, open calls rely on citizens' self-assessment and self-selection (Afuah & Tucci, 2012; Franzoni & Sauermann, 2014). In the second case, project leaders

target and invite specific groups of citizens to participate. This latter approach to recruiting entails the assessment of citizens as sources of knowledge.

One factor that influences the assessment of citizens as sources of knowledge is the extent to which project leaders know those groups of citizens. In other words, prior knowledge is necessary to be able to recognize the value of new sources of knowledge (Cohen & Levinthal, 1990). Another factor that appears to affect the evaluation of individuals as sources of knowledge is the *shared superordinate social identity* (Kane et al., 2005) between project leader (assessor) and targeted citizens (assessed). Experiments have shown that individuals are more likely to accept the knowledge of those with whom they share some social similarity, that is, a shared superordinate social identity (Kane et al., 2005).

Social identity refers to the *'sense of belonging to a social aggregate'* (Kane et al., 2005, p.57), such as a profession or community of practice. Identity develops while learning or performing the job/task that characterizes a community or profession (Lamb & Davidson, 2005; Wenger, 2000). Thus, people with a similar educational background or similar work practices are likely to share a superordinate social identity. Moreover, social identity is driven by and contributes to the reduction of uncertainty, because it involves categorizing people into groups, which helps in predicting what people in those groups are like, and how they might act (Hogg, Abrams, Otten & Hinkle, 2004). It is therefore expected that, to reduce knowledge uncertainty, citizen science project leaders will base the assessment of citizens on the similarity to their own educational background and interest in a specific topic and academic discipline (Lamb & Davidson, 2005).

To evaluate citizens' contributions, some project leaders look for experts among the group of regular participants. This search for citizen experts involves both assessing citizen participants as sources of knowledge, and assessing the outcomes of their knowledge. That is, people who have a relevant educational background and experience, and whose contributions are of higher quality, will be more likely to be asked to act as peer-expert reviewers. The assessment of potential experts among the group of participants is therefore based not only on their shared identity with the project leader, but also on the quality of their knowledge outcomes. The evaluation, acceptance or rejection of their knowledge outcomes (i.e. contributions) depends on the quality standards that characterize each scientific field or profession (Robertson et al., 2003). Consequently, the evaluation of knowledge outcomes is performed differently and according to different criteria depending on the field and task at hand.

The citizen science literature suggests that evaluating quality may require other methods than those used in the scientific field of the project leaders (Wiggins & Crowston, 2011). However, my study shows that, though assessment methods are adapted to allow for the knowledge divide between scientists and citizens, the evaluation of citizen contributions follows similar methods and adheres to the same quality criteria as in the academic field that they support. This can also be explained by the role of the project leaders' social identity in shaping the assessment of knowledge outcomes. The social identity of project leaders, who are usually employed as professional researchers, is influenced by the core practices of their

scientific community, such as the publication of scientific findings and the review process that precedes it (Lamb & Davidson, 2005). Therefore, since expert reviews and academic publications are the common means to ensure quality among scientists, it is not surprising that project leaders apply similar approaches to assess and ensure the quality of citizen science outcomes.

Following-up on the key role of social identity in the assessment of knowledge, one future research direction might be to study the effect that leading a citizen science project has on scientists' professional identity. Could the new practice of leading a community of citizen scientists change project leaders' attitudes towards quality and what it means to conduct scientific research?

Another area for future research could be the link between knowledge assessment and performance, especially when performance refers to the quality of outcomes. Assessment of knowledge outcomes is essential for supporting learning and improving quality. Providing citizens with feedback on the results of knowledge assessment could be seen as a form of self-tracking of (mental) performance (Pantzar & Ruckenstein, 2014). Not all citizen science projects provide citizens with specific feedback about their performance. Sometimes feedback is ad-hoc or embedded in revisions of the project's guidelines. Providing standard visualizations of individuals' performance could be a way to support self-awareness and learning (Pantzar & Ruckenstein, 2014), but it could also discourage citizens from further participation. Future research could explore the effects of specific individual feedback on participation, learning and performance improvement.

5.2.2 Quality, learning and retention

It is generally accepted that citizens can gain knowledge about specific scientific topics and about the scientific research process by directly participating in citizen science projects (Masters et al., 2016). In Chapter 3, I have shown how participation for longer periods of time results in learning and quality improvement. In the context of citizen science, this specific type of learning, which I have called extra-organizational learning, depends on participant retention.

Extra-organizational learning not only shows the importance of recruiting large numbers of citizen participants but, most crucially, also points to the need to retain participants in the project. People who stay engaged in a citizen science project for longer periods of time are more likely to learn and improve the quality of their contributions. Though the retention of citizen participants is outside the scope of this dissertation, I believe that the findings of Chapter 3 provide opportunities for further research about learning and retention.

Since citizen scientists are volunteers, it makes sense to use what has been learned about recruiting and retention from the literature on volunteering. For instance, Chapter 3 of this dissertation has shown that retention of participants is essential to ensure and improve the quality of citizens' contributions over time, while studies on volunteering argue that learning and development opportunities contribute to greater commitment to the organization (or project) and to the intention to continue participating as volunteer (Newton, Becker & Bell,

2014). In other words, this suggests that the mechanisms adopted by the organization to support learning, might have both a direct and indirect effect on extra-organizational learning. Training, guidelines and feedback support knowledge sharing and learning but also influence the likelihood of participant retention (Newton et al., 2014). An important question for future investigation would be the effectiveness of each of these activities (training, guidelines and feedback) in supporting learning.

Furthermore, current literature on volunteering indicates a connection between motivations to volunteer and volunteers' satisfaction and retention. For instance, if the volunteering experience fulfils volunteers' motivations and expectations, volunteers are more likely to continue investing their time and knowledge in the project (Snyder & Omoto, 2008). In addition, people with different motivations for volunteering have different preferences about opportunities for learning and development (Newton et al., 2014) and rewards (Phillips & Phillips, 2010). Future research could explore whether this is also the case in citizen science projects.

It is difficult to avoid that citizen volunteers eventually leave for whatever reason. However, the literature on volunteer retention suggests that discovering participants' motivations for joining a project can provide valuable information for using the right learning and reward mechanisms to increase volunteer retention (Phillips & Phillips, 2010; Snyder & Omoto, 2008). For instance, citizens interviewed in the course of my research were mainly motivated by their interest in the content of the materials they transcribed, the task of transcribing (or translating), and the sense of purpose given by contributing to science. They also said that they enjoyed the task and mentioned a sense of accomplishment when they performed well, and when they saw or expected to see their work online or used in scientific research. Future research on citizen science could investigate the effect that learning and rewards might have on citizens' motivations to continue contributing to a project.

Another factor that might have an effect on learning and retention in citizen science could be participants' educational background and prior experience. A common assumption would be that a relevant educational background or prior experience could have a positive effect on learning, retention, and hence the quality of citizens' contributions. Yet research is needed to investigate the extent and pace of learning between citizen participants with different educational backgrounds and experience with the task.

Finally, in Chapter 3, I assumed that the complexity of the task influenced the learning process. However, the available research data did not allow an examination of how complexity affects learning. It could be that task complexity slows down the learning process or, alternatively, complexity could be a challenge that makes citizens willing to exert more effort and hence learn faster. More quantitative data are needed to examine the relationship between task complexity and learning in the context of citizen science.

5.2.3 Quality and openness

The need for quality seems to work against the originally open character of citizen science. I have identified two specific instances in which the need for quality influences openness. First, though participation in citizen science is said to be open (Franzoni & Sauermann, 2014), the existence of targeted calls appears to limit openness to only those who are considered to be sufficiently interested, knowledgeable or motivated to perform a project's specific task. Second, despite the relative openness of participation in citizen science and the usual open access availability of the final outcomes of citizen science (Franzoni & Sauermann, 2014), intermediate outcomes and/or contributions are not always publicly accessible. Typically, the outcomes of citizen science become open after citizen contributions have been assessed and corrected, that is, when experts consider that contributions fulfil the required scientific standards of their field. In this dissertation, I have shown that openness is relative and that there are varying degrees of openness in the different steps of the research process (Whyte & Pryor, 2011).

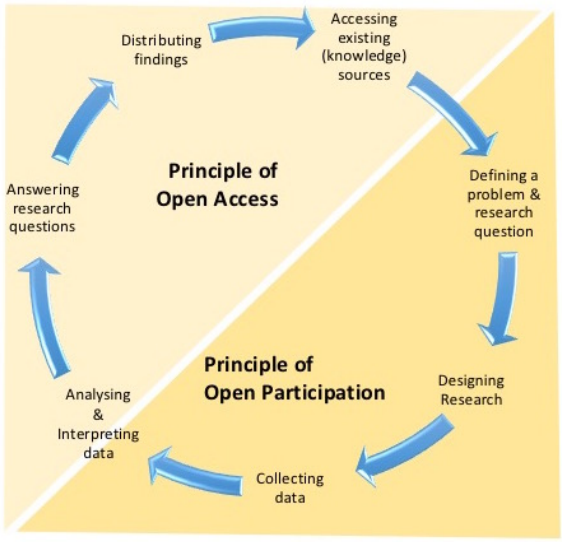


Figure 5. 1. Principles of openness in citizen science

Citizen science belongs to a group of new research practices characterized by a tendency towards openness. Opening-up research practices refers to the increasing *"freedom to access, use, reuse and modify data and information as the basis for creativity and innovation*" (Peters & Roberts, 2011, p. 31-32). Citizen science, like other open science phenomena, is driven by two main principles: sharing and egalitarianism (Peters & Roberts, 2011), or in other words, open access and open participation (see Figure 5.1).

Open versus targeted participation

The principle of open participation in citizen science refers to the equal opportunities, or freedom, that every citizen has to participate (Peters & Roberts, 2011, p. 32). In this dissertation, I have shown that some projects have a wide-open recruitment approach, while others target people who have specific interests, knowledge or motivation to participate. That is to say, some projects use open calls while others issue targeted calls. Recruiting specific

groups of people through targeted calls seems to restrict the freedom to participate, because only targeted people become aware of a project and have the opportunity to take part in it. Despite the use of targeted calls, I have not heard of anyone being excluded from participation. One can therefore conclude that different recruiting activities in citizen science result in different levels of openness of participation (Whyte & Pryor, 2011).

Community versus public data sharing

The principle of open access (or sharing) means expanding the dissemination of research findings, data or code as widely as possible *"to all who are interested in it and all who might profit by it"* (Willinsky, 2006, p. 5). It has been said that the outcomes of crowd or citizen science, whether final or intermediate results, are usually open access (Franzoni & Sauermann, 2014). However, the projects that I have studied show different levels of openness with regard to intermediate results, and most of them did not make intermediate data visible to the general public. It seems that, for quality reasons, not all scientists feel comfortable with having intermediate data open and available for everyone to read and use. Scientists appear to feel that they might receive complaints from people reading or wanting to use data that have not yet been checked for quality. This contradicts the idea of opening-up the scientific process to the public. One could say that, in citizen science, intermediate data follow a 'community sharing' approach, where data are only accessible to the members of a specific community, while final results are publicly shared (Whyte & Pryor, 2011).

In addition to the need for quality, there seems to be a further reason for the different degrees of openness between intermediate and final outcomes of citizen science: the publishing paradigm. The publishing paradigm is associated with traditional science, in which researchers keep their data and intermediate results for themselves and only share their research outcomes in the form of a finished publication (Franzoni & Sauermann, 2014). This is due to the established scientific quality mechanisms (i.e. peer-review process) and reward systems (Franzoni & Sauermann, 2014; Lamb & Davidson, 2005). The consequence of this paradigm for citizen science is that projects are driven by the idea of publishing a finished and final (research) product. Though this is understandable, current Web 2.0 technology already facilitates the creation of open digital (research) products or databases, which can be expanded and modified over time by their creators, as well as other members of the public. Such open digital (research) products or databases allow greater transparency and authentication of the research process and its outcomes (Franzoni & Sauermann, 2014).

Publishing is essential for professional scientists' identity because they gain legitimacy and recognition within their scientific community (Lamb & Davidson, 2005). It is therefore not surprising that they adhere to traditional finished-publication modes instead of sharing intermediate results that do not yet meet scientific quality standards. An alternative explanation is that making intermediate results available could increase publishing competition or impede publication in established channels (Franzoni & Sauermann, 2014; Lamb & Davidson, 2005).

5.3 Implications for practice

The importance and challenge of delivering citizen science outcomes that fulfil scientific quality standards remains a hot topic among citizen science practitioners, as shown in the first issue of the 'Citizen Science: Theory and Practice' journal, published in May 2016. How to ensure quality in citizen science is also one of the questions that I was asked by scientists who were thinking of launching a citizen science project. At this point, while wrapping up the research conducted over the last four years, I would advise future project leaders and research organizations to: (1) invest time and effort in supporting the learning process of citizen participants; (2) consider beforehand the constraints and affordances they expect from technology for their specific project; and (3) make intermediate outcomes or small collections of final outcomes, open and available as soon as possible.

Investing time and effort in helping citizen participants to learn how to perform the task according to certain standards really does pay off, because the quality of their contributions increases and the time required by project leaders to assess and improve those contributions decreases over time. Some scholars believe that a trade-off between learning and the speed of output delivery is likely to occur, because of the pressure to obtain useful data for research (Masters et al., 2016). However, I have shown that investing in knowledge management (Chapter 2) and supporting extra-organizational learning (Chapter 3) are necessary to foster high-quality outputs at a reasonable pace. Spending time on sharing knowledge, organizing tasks, assessing and improving contributions, and giving feedback contributes to learning and higher-quality outcomes. Moreover, as people learn and quality improves, less time is needed to assess and amend contributions.

Considering beforehand the possible actions that technology enables (or does not enable) the project to perform is important for managing and meeting expectations. Literature on technology for citizen science discusses the need to design technology that satisfies and motivates participants (Prestopnik & Crowston, 2012). One way to gain efficiency is by joining a multiple-project platform, which not only makes it possible to recruit more people (Franzoni & Sauermann, 2014), but usually already affords secured and standard ways to register participants, submit contributions, and add instructions (Prestopnik & Crowston, 2012). However, the types of tasks, materials and motivations of participants differ across projects. Standardized features of multiple-project platforms may not always be suitable for the way a task is organized or the characteristics of the materials, or be motivating enough for participants to remain in a project. Consequently, project leaders should critically assess the affordances (Chapter 4) of different technological options before joining any platform, and consider building the functionality that best fits the project (Prestopnik & Crowston, 2012).

And lastly, making the intermediate outcomes of citizen science open and available to the public is not only useful for facilitating authentication of collected and processed data (Franzoni & Sauermann, 2014), but is also important for keeping participants motivated, showing the progress made and encouraging others to join the project. As explained above, citizen participants are partly motivated by a sense of purpose in contributing to science, and

are glad to see their work published online. Giving citizen participants a sense of accomplishment by acknowledging their contributions and opening-up intermediate and final outcomes might be a good reward. This is in line with the volunteering literature, which indicates that volunteers usually prefer intangible rewards, especially rewards that convey the organization's appreciation of their time and effort (Phillips & Phillips, 2010).

5.4 Reflection

In this section, I reflect on two important topics of my doctoral research trajectory. First, and most importantly, I consider the research approach that I have taken to study citizen science, and what I have learned about research design and methods along the way, including limitations. And second, I discuss a number of issues around citizen science that I have often come across when reading and talking about this phenomenon, but that were not directly linked to the research question.

5.4.1 Research limitations and approach to citizen science

To study how the need to ensure the quality of outcomes affects citizen science, including project leaders, citizens, the activities in which they engage in and the technology they use, I have taken an inductive multiple-case study approach. Using an inductive research method was the most suitable way to examine quality in citizen science, because of: the relative newness of the phenomenon and the lack of specific theory; the existence of equifinality, that is, the outcomes of all the projects fulfilled the quality standards set by the project leaders; and the fact that a quantitative measure for the quality of citizens' contributions was not available for all the projects (Eisenhardt, Graebner & Sonenshein, 2016). Using an inductive approach entailed gathering and analysing data that would answer the research question and contribute to theory building (Eisenhardt et al., 2016).

Case studies are particularly useful when the research objective is to investigate an ongoing phenomenon as it happens in real life (Yin, 2014), such as the phenomenon of citizen science and the strive for quality in that context. Since citizen science takes place in the form of projects with their own distinctive context and characteristics, I addressed the research question by studying multiple citizen science projects. Gathering and analysing data from multiple cases and through multiple sources in the context of citizen science proved to be an interesting challenge.

First, following multiple real-life cases is far from similar to replicating an experiment, as is sometimes argued (Yin, 2014, p. 57). The number of available cases suitable for my research purpose and interest was limited. Furthermore, the cases that matched the profile were projects that had already been started or were near completion. Hence, I was not able to observe the process and decisions around the phase of project design, and I only knew whether a case was a good replication of previous ones when I started researching that case and comparing it with the others. Though I am confident that my findings give a good picture of the process of ensuring quality in citizen science, I urge researchers interested in this topic to study projects from their inception and to consider project and task design. Based on the

above, I have come to realize that, rather than replication, the real-world context of my research was key to selecting suitable multiple cases (Eisenhardt & Graebner, 2007).

In addition to collecting and analysing data from multiple cases, I also used multiple data sources. I not only interviewed people, but also observed different types of meetings, gathered and analysed documents and e-mail messages, analysed quantitative data, explored two of the online platforms, and even experienced first-hand the task of transcribing. The purpose of gathering data from multiple sources was to validate the findings between sources and to provide a complete account of quality in citizen science. For instance, insights from observations were used in asking questions during interviews, and interviewees' comments were confirmed with data from documents (such as manuals and minutes of meetings) and observations. However, data collection from observations was partly constrained by the nature of the phenomenon itself. Citizen science projects are characterized by voluntary and distributed participants, who are not only dispersed geographically but also perform their tasks wherever and whenever they like. Observing the activities of people participating in citizen science was therefore limited to the occasions when they physically met for project meetings or training sessions, or during face-to-face interviews. I could not directly observe the exact occasion when they normally performed their tasks, as one might when studying more traditional organizational phenomena. Moreover, conducting face-to-face interviews was time-consuming because it required travelling to different areas of the Netherlands. In the case of 'Transcribe Bentham' this was even more challenging, because the interviews were conducted via Skype, with people located in different parts of the world. On those occasions, I had to consider the time difference and the varying quality of Internet connections. I believe that engaging in a citizen science project as part of the organizing team could help future researchers deal more easily with these issues.

An interesting aspect of my research, from which I learned a great deal, was the analysis and merging of quantitative and qualitative data to answer the research question of Chapter 3. Quantitative data were gathered prior to and for different purposes than my research on quality in citizen science. This resulted in an iterative and time-consuming analysis process. Yet the data proved to be highly valuable in confirming my expectations about learning and quality in citizen science. They also helped me to select project participants and prepare for the interviews. Though quantitative findings about super-transcribers were confirmed and clarified with qualitative data, I was not able to interview people who contributed only one page. Researchers interested in participant retention in citizen science could learn more about why participants leave a project by interviewing those individuals. Furthermore, because I only had quantitative data from one project, I could not assess the efficiency and effectiveness of the different activities used to support learning and achieve quality. Future research could gather both quantitative and qualitative data from several projects, to assess the efficiency and effectiveness of different activities in supporting learning and quality.

Finally, the inductive and mostly qualitative approach of my research directed the focus of Chapter 4 towards technology affordances. I did not originally plan to study affordances, but the comparison of data about technology across the cases indicated an opportunity for further theory building. It would have been better if I had considered affordances from the

beginning. In that case, I could have looked for a project in the process of adopting technology and asked interviewees specific questions about that matter. However, given the fixed period of my research and the purpose of studying the phenomenon in real life, the likelihood of finding a project in that exact phase of development would have been small.

All in all, though investigating a new phenomenon may have limited the possibilities for choosing cases, and following multiple cases and gathering data from multiple sources was time-consuming, these challenges made my research process even more enriching from a personal and academic perspective.

5.4.2 Ethical issues around citizen science

In addition to the need for quality, ethical issues are often mentioned in the citizen science literature. I would like to reflect here on this topic and discuss what I have learned in the course of my research. Ethical issues in citizen science are usually related to the voluntary and non-paid character of the tasks that citizen participants perform. Issues arise from the notion that performing a task in a citizen science project is the same as working for free. This could be considered a form of exploitation.

Citizen science projects are usually initiated by non-profit research organizations, which are increasingly under pressure to reduce costs and find new ways to fund their research projects (Estermann & Claeys-Kulik, 2013). Within this context, research-supporting tasks, such as transcription of documents, are typically the ones being outsourced through citizen science projects. Relying on unpaid citizens to perform research-related tasks, because of public funding difficulties, could put the jobs of current and future scientists at risk (Riesch & Potter, 2014), and might lead governments to falsely believe that those tasks are unnecessary or that research organizations can manage with less funding. These are understandable and important concerns that should be considered by research organizations and their funding bodies.

Despite these concerns, citizen science is anything but exploitative. Among the arguments in defence of this new form of organizing research, self-selection is the first and most obvious one. Citizens voluntarily self-select themselves to participate in citizen science and, just like in other forms of voluntary online participation, they can leave a project if they are unsatisfied (Brabham, 2011). Second, citizen science projects are not only aimed at scientific productivity, but their organizers also seek to make scientific data and information widely available, engage citizens with scientific topics (i.e. outreach), and educate and increase the knowledge of the general public (Wiggins & Crowston, 2011). This is related to a third argument in favour of citizen science, namely that participation is often driven by the human need to be part of something perceived as meaningful, such as science (Owens, 2013). Moreover, many citizens see their participation in such projects as a hobby. During interviews in my research, they referred to their tasks not as ‘work’ but as a hobby, for which they did not have deadlines or a boss who pressurized them to produce their output sooner rather than later.

In addition, as my research has shown, engaging in citizen science does not mean that data and information are gathered or processed for free. Citizen science projects require dedicated project leaders to manage citizens' knowledge work, as well as enough funding to acquire the technology and materials to facilitate citizens' tasks. In fact, some researchers have estimated that investing in full-time employees to perform such tasks would be more time- and cost-efficient than a citizen science project (Causer et al., 2012).

Therefore, rather than exploiting, the organization of citizen science projects seems a good means to open-up the scientific research process and fulfil society's thirst for knowledge and people's need to become part of something greater.

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Appendix A (Chapters 2 and 4)

Interview guide for semi-structured interviews with project leaders / coordinators

- **Introduction:**
  - Shall we first introduce each other? I will tell you about myself and my research.
  - Could you please tell me about yourself and how have you become project leader / coordinator of this project?
- **Before crowdsourcing the task / before starting the project:** [Not for 'Gouda on Paper']
  - How was the transcription done before crowdsourcing?
  - Who did it? (type of employees)
  - What do you need the transcription for?
- **About the start of the project:**
  [Questions aimed at learning about the choice for crowdsourcing/citizen science, the organization, reasons for selecting specific technology]
  - Could you please explain how the project was set-up? How did it start?
    Prove if not mentioned:
    - Whose idea was it?
    - Why crowdsourcing?
    - When did it start? And How long did it take?
    - Who was involved? Who took the decisions? (decisions about: technology, team...)
- **About the project:**
  [Questions aimed at learning about the assessment process: type of participants, knowledge, selection, task complexity, who decides, what criteria do they use, role of technology]
  - What kinds of people participate in the project?
  - Can volunteers register for the project? Or are they selected? How are they selected?
  - Could you please tell me how the project works? From beginning to end, how does exactly work?
  - Does technology help to ensure quality?
  - Who decides whether the output (transcription) is good enough?
  - When is it good enough? (criteria)
  - *Do participants get feedback about their work? [added in August 2013]*
  - When is the project finished? When do you know the project is ready?
    Prove if not mentioned:
    - *Do you use a manual? [added in August 2013]*
    - *Do participants get training? [added in August 2013]*
    - *Who and how is the transcription assessed and corrected? [added in August 2013]*
- **Last question:**
  - With your current experience, what would you do differently next time?
- **Thank and close:**
  Thank you very much for your time and participation in my research.
  It was a pleasure to speak to you.

Interview guide for second / follow-up interviews with project leaders / coordinators

[Some second interviews included observation/demonstration]

- **Introduction:**
  - I already know how the project works. [Summarize to confirm]
  - But I still have a few questions in relation to what I have heard so far.
- **Assessment of knowledge source:**
  - How are the roles distributed among people?
    [Prove: How do you determine who transcribes, who corrects and who performs the editorial control?]
  - Is this always (from the beginning of the project) been this way? Has this changed in the course of the project? How has this changed? Why?
  - How is this going to continue?
- **Assessment of transcriptions:**
  - Could you please show to me and explain how you perform the assessment and/or the final editorial control?
  - Is there a difference between these two?
  - Could you please explain what do you exactly check and why? Say, if I had to do this tomorrow, what would I need to do and know?
  - What is important to do well and why?
  - What are the most common problems/mistakes? Can you give an example?
  - When do you know that the transcription is ready/good enough? Why?
  - Are there other people involved next to the volunteers, project leader, coordinator? If yes, what do they do?
- **Thank and close:**
  Do you want to add something? Or do you have any questions?
  Thank you very much for your time and participation in my research.

Interview guide for citizen participants

- **Introduction:**
  - Shall we first introduce each other? I will tell you about myself and my research.
  - Could you please tell me about yourself and how have you become involved in this project?
- **About the start of the project:**
  - Did you register/apply for the project or were you asked to participate? How did it go?
    Prove if not mentioned:
    - If registered: When did you register? Why did you do that?
    - If asked: Why were you asked to participate?
  - Did you get any training? Why? How did it go?
- **About the project:**
  - Could you please tell me how the project works, from begin to end?
  - Could you please show to me how you do the transcription / correction?

  Prove if not mentioned:
  - Who does what? What is your role? What other roles are there? What do others do?
- **Observation:**
  - Could you please show to me how you do the transcription / correction?
  - What is important to do well? What is important to look at?
  - What are the most common problems/errors? How do you know that?
  - When do you know that the transcription is ready/good enough to publish?
- **Thank and close:**
  Thank you very much for your time and participation in my research.
  It was a pleasure to speak to you.

Observation & Interview guide for project staff assessing contributions

[Observation and interview aimed at learning how the assessment of transcriptions is done]

- **Introduction**
  I already know how the project works. [Summarize to confirm]. But based on what I have learned so far, I still have a few questions.

- **Knowledge assessment (interviewees call it 'control'):**
  [Questions aimed at learning about the activities done, in what order and why]
  - Could you please show me and explain to me how you do the 'control' and/or the final edition? Is there a difference between these two?
  - Could you please explain what you exactly look at and why? Say, If I were to do this tomorrow, what should I do or need to know?

  [Questions aimed at learning about the quality criteria, what they are, why they are important, what consequences exist if not done, what mistakes are often made, how are they corrected. Make sure to have an answer on: what (object & criteria); how (process, steps, actions); why (norms); what happened before and what will happen after (division of labour)]
  - What is important to do well? To check? Why?
  - What are the most common problems or mistakes? How do you know that? And could you please give an example?
  - When do you know that a transcription is ready or good enough? Why?
  - Are there other people involved in the project next to the volunteers, and yourself? (for example managers, colleagues, users of the data) What do they do?

- **Thank and close:**
  Do you have anything else to add? Or do you have any questions for me?
  Thank you very much for your time and participation in my research.

Appendix B (Chapter 3)

Interview guide for citizen participants

- **Introduction**
  [Questions aimed at learning about the Open Call, self-selection, motivation, background (edu. & prof.) and experience]
  - Shall we first introduce each other? I will tell you about myself and my research.
  - How did you hear about this project?
  - Why did you join this project?
  - Did you have prior experience with transcribing?

- **Participation in Project:**
  I know in general about the project, but I'd like to hear from experienced transcribers, in your own words:

  [Questions aimed at learning about the project activities, including the selection of manuscripts, the transcription (text and mark-up), feedback, and contact with project leader]
  - Can you shortly explain how the project works? So, you make an account, then what? What do you do then?

    Prove if not mentioned:
    - How do you select the folios? Do you select particular type of folios? Or random? Why? Do you get feedback? How does it work? Do you read it? Do you compare your work with the corrected version?)

  [Questions aimed at understanding whether and how people socialize and collaborate with other participants in the project]
  - Have you ever had (online) contact with other transcribers in the project? Why yes/no? If no, what would motivate you to participate in online discussions with other transcribers?

  [Questions aimed at learning about the level of activity, reasons for engaging in this particular project / prove interest in simpler tasks (retention)]
  - How often do you transcribe? Why?
  - Would you continue transcribing if the manuscripts were more simple?
  - Have you considered other projects? Why?

  [Questions aimed at understanding the reasons for stopping participation (retention)]
  - There are people who just contribute one or a few transcriptions. What do you think is the reason they stop participating?

  [Questions aimed at understanding more about Learning and Training]
  - How did you learn to use the transcription desk and the mark-up tool bar?
  - What would you recommend to someone who is just starting in the project to do in order to learn?

Prove if not mentioned:

- What is your opinion of the guidelines?
- What do you think about the feedback? And about the history option to compare versions?

- **Thank and close:**

  I do not have any more questions. I really liked talking to you. Do you have any questions yourself? Or would you like to add or tell me something that I did not ask? Many thanks for your time and participation in my research.

Interview guide for semi-structured interviews with project leaders / coordinators

- **Introduction**

[Questions aimed at learning about the motivation, background (edu. & prof.) and experience as project leader and with the task]

Tell about myself and my project. Then ask:

- How and why did you join this project?
- Did you have prior experience with crowdsourcing?
- And with transcribing?

- **Decisions about the Project:**

  I know quite a lot about the project as it is now, but I'd like to know more about how you got where you are, for instance:

  [Questions aimed at understanding the choice for crowdsourcing]

  - Why and how did your team decided to start a crowdsourcing project? Were there other options to perform the task / achieve objective?

  [Questions aimed at understanding the selection of technology]

  - How did you and your colleagues decided about the technology to be used?

  [Questions aimed at understanding development of and changes in the guidelines]

  - Can you shortly explain why and how you developed the guidelines?
  - Have the guidelines changed since you first launched the transcription desk? Why did you change them? (If yes, request a copy of prior versions)

  [Questions aimed at understanding how they facilitate the selection of folios]

  - Was the categorization of scans/folios the same as it is now already from the beginning? If not, please explain how this developed.

  [Questions aimed at understanding the norms in completing other people's work]

  - Do people ask for permission or advice about completing partially transcribed documents? (If yes, request a copy of messages as example)

  [Questions aimed at understanding how they coordinate and perform quality control]

  - Why and How did you decided on the current way of controlling the quality?

  [Questions aimed at learning about the community and the division of labour]

– What other people are involved in the project? And what are their roles/tasks?

[Questions aimed at finding out how they consider the feedback from participants]

– I believe you improved the encoding toolbar based on participants' feedback. Have you changed other things in the transcription desk or the way of organizing based on participants' comments?

- **Recommendations for others:**

[Question aimed at learning about success factors]

– What would you say are the success factors of Transcribe Bentham?

[Question aimed at finding out recommendations for practice]

– What would you recommend to others who are considering crowdsourcing in your field? (in terms of technology, organization of the project, other…)

- **Thank and close:**

  I do not have any more questions. I really liked talking to you again.
  Do you have any questions yourself? Or would you like to add something else?
  Many thanks for your time and participation in my research.

Summary

Nowadays, the organization of work and leisure time, the way we communicate and explore the world, are no longer subject to space and time constraints. The development and growth of the Internet has been essential in the emergence of new forms of organizing human activities. This dissertation examines the phenomenon of citizen science, which refers to a participative form of organizing and conducting scientific research, by involving citizens in the collection and processing of data through the Internet. In citizen science, citizens voluntarily contribute their time and knowledge to perform specific tasks to support scientific research projects. Citizen science has the potential to improve the public understanding of science, increase the time and resource efficiency of research projects and reach individuals with specialized or rare knowledge (Brabham, 2013; Franzoni & Sauermann, 2014; Shirk et al., 2012).

However, the quality of citizen science outcomes is a recurring point of concern in the scientific community in general (Oomen & Aroyo, 2011; Riesch & Potter, 2014; Sheppard, Wiggins, & Terveen, 2014; Wiggins et al., 2011). This concern stems from the need for quality of information inherent to scientific research, the existence of knowledge differences between scientists and the public (Miller, 2001), and the knowledge uncertainty of involving unknown citizens into a research project. That is, compared to other citizens, scientists go through lengthy and rigorous training to become experts in specific topics. Moreover, citizen science projects are characterized by open participation, meaning that citizens unknown to the project leader are free to participate. Quality concerns about the outcomes of citizen science seem therefore well justified.

In this dissertation, I seek to understand *how the need for quality is addressed in the organization of citizen science projects*. To this end, I have carried out an extensive qualitative multiple-case study by following and comparing five citizen science projects in the knowledge-intensive field of the humanities. This research approach and the context of my empirical study are discussed in Chapter 1. The following three chapters focus on quality and the organization of citizen science projects, the role of citizens and the use of technology.

Chapter 2 examines how the need, that project leaders have, for ensuring the quality of outcomes shapes the way of working and organizing in citizen science projects. Since citizen science often involves knowledge work, I approach this question through a knowledge management lens. The knowledge management challenge lies in ensuring quality in a context with knowledge differences and a priori uncertainty. To deal with this challenge, project leaders invest their time and efforts in managing and evaluating knowledge work. Project leaders

ensure quality outcomes by acquiring and sharing knowledge, organizing and assessing knowledge work in different ways. The different ways in which knowledge work is managed depend on: the number of citizen participants, resulting from the type of recruiting approach (open versus targeted calls); their geographical distribution; the characteristics of the tasks; and the type of technology used. The way knowledge is assessed depends on whether and how project leaders evaluate the source and the outcome of knowledge. The evaluation of citizens as sources of knowledge appears to be influenced by: 1) the extent to which project leaders know about participants' level of expertise, and 2) the similar social identity between project leaders and citizens (Kane et al., 2005; Lamb & Davidson, 2005). The assessment of knowledge outcomes depends on the quality standards that characterize each scientific field (Robertson et al., 2003).

Chapter 3 considers how the need for quality outcomes affects citizens' efforts and learning process. Citizens are individuals external to research organizations but connected to them through their voluntary participation in citizen science projects. Citizens' learning process and the improvement of their contributions are essential for ensuring that the outcomes of citizen science projects satisfy scientific quality standards. To examine this learning process, I build upon the 4I framework of organizational learning (Crossan et al., 1999; Zietsma et al., 2002) and introduce the concept of 'Extra-organizational learning'. Extra-organizational learning refers to the learning process of individuals external to an organization, who perform tasks essential for the activities of that organization. I zoom into one of the five studied cases and empirically examine how extra-organizational learning takes place and how one research organization facilitates it. The study shows that extra-organizational learning takes place when citizen participants remain involved in a project for longer periods of time. This type of learning is supported with guidelines and feedback, which are used to increase skills and reduce skill variability among citizen participants.

Chapter 4 covers the use of technology in citizen science projects and examines why technology is sometimes used differently than intended by its designers. Citizen science projects employ different technologies for different purposes. Web-based platforms, for instance, are used to integrate contributions from distributed citizens. To understand why a platform may be used differently than intended, I zoom into one citizen science project that illustrates this situation. I analyse the case by combining the concept of affordances and activity theory. Technology affordances refer to the potential actions that technology allows us to do in specific contexts (Hutchby, 2001). I focus on the distinction between designed, perceived and actualized affordances and show that the use of technology is expected to be different than intended when affordances are designed, perceived and actualized within different activity systems. The studied case indicates that even when affordances are not actualized as expected, the resulting unintended use of technology is meant to ensure quality outcomes. Therefore, the need for quality in citizen science means that the use of technology can take unanticipated turns without compromising the project's goal of scientific quality.

Taken together, these three chapters show that, the need for quality information resulting from citizen science involves project leaders investing their time and efforts in managing knowledge work. In other words, project leaders engage in knowledge management to support

the performance of activities and the learning process of citizens. At the same time, citizens learn and improve the quality of their contributions, which are standardized and integrated with the help technological artefacts that are sometimes used in unintended ways.

Overall, this dissertation contributes to the literature on knowledge management by emphasizing the importance of knowledge assessment, expands organizational learning theory by adding the process of extra-organizational learning, and integrates the literature of technology affordances and activity theory. Based on these findings, I would recommend research organizations to: (1) invest time and effort in supporting citizen participants' learning process; (2) consider beforehand the constraints and affordances of technology expected in their specific projects; and (3) open-up the intermediate outcomes of citizen science.

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"Caminante, no hay camino: se hace camino al andar."

Traveller, there is no path: paths are made by walking.

Antonio Machado 1875–1939

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