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# Participatory Design for User-generated Content: Understanding the challenges and moving forward

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**Abstract.** Research on participatory design (PD) dates back to the 1970s, and has focused historically on internal organization settings. Recently, the proliferation of content-producing technologies such as social media and crowdsourcing has led to the explosion of user-generated content (UGC) that originates outside of organizations. Participative challenges in UGC differ from those in traditional organizational, as well as other distributed multi-user, settings; e.g.; open source software, multi-party systems. UGC is an interesting emerging domain and exploring PD in this context may con-

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tribute to knowledge and practices in PD itself. In this paper, we analyze the challenges and opportunities associated with PD in organization-directed UGC development, illustrate these with two UGC projects, and propose fruitful directions for future research.

*Key words:* participatory design, distributed participatory design, user-generated content, crowdsourcing, social media, citizen science.

## 1 Introduction

The proliferation of technologies and platforms that allow people to create digital content has generated a massive volume of data created by members of the general public. This information can come in a variety of forms—such as tags, tweets, product reviews, forum posts, digital artwork, video, and audio—collectively known as ‘user-generated content’ (UGC) (Levina and Arriaga 2014; Lukyanenko et al. 2014a; Susarla et al. 2012). Major sources of UGC include massively multi-user social networks; e.g.; Facebook, Twitter, Tumblr, crowdsourcing (platforms where users are asked to perform specific tasks, see Brabham 2013; Doan et al. 2011; Li et al. 2016), forums, wikis and community portals. Additionally, UGC is often generated via e-commerce, corporate, and news websites that permit people to rapidly produce, share and consume content; e.g.; product reviews, comments on news articles, user ratings; (Faraj et al. 2011; Gao et al. 2015; Goh et al. 2016; Miranda et al. 2016; Wattal et al. 2010; Zwass 2010).

Our interest in UGC is driven by the increasing number of organizations wishing to use UGC in decision making and operations. Contributions of ordinary people promise insights on customer reactions to products and services, can be used to identify trends, and can contribute to developing better products and services (Barwise and Meehan 2010; Culnan et al. 2010; Li et al. 2016). Through UGC, governments can engage with citizens and leverage their knowledge in policy-making, governance and operations (Johnson and Sieber 2012; Sieber 2006). Applications of UGC are growing in areas such as crisis management, healthcare, and scientific research (Bonney et al. 2014; Gao et al. 2015; Goodchild and Glennon 2010; Majchrzak and More 2011; Show 2015).

Although organizations can mine and then repurpose existing user-generated data sources; e.g.; Twitter, Facebook, Flickr, YouTube, Wikipedia, forums, blogs; (Culnan et al. 2010; Schuff et al. 2010; Susarla et al. 2012; Wattal et al. 2010), to fully benefit from UGC organizations often develop custom-built online platforms to elicit specific information. As Prpic et al. (2015, p. 80) contend, “[c]rowds need to be constructed - they hardly ever pre-exist”. This results in ‘organization-directed’ or crowdsourced UGC.<sup>1</sup> We further focus on a special kind of organization-directed UGC—public projects as opposed to projects which are of explicit commercial value. Specifically, we assume a scenario when an organization wishes to engage diverse audiences (the crowd) to produce information about some phenomena of interest to the organization. In this context, user participation in the online project is primarily voluntary and users are typically unaffiliated with the organization; e.g., they have no pre-existing contractual agreements or product experiences. While ideas and arguments in the paper apply (differentially) to other

types of UGC and other contexts (including distributed corporate settings), here we consider only organization-directed UGC focusing on the public good.

To illustrate our object of research, consider a highly popular project, eBird. Cornell University's Ornithology Lab (the organization) created a crowdsourcing website eBird ([www.ebird.org](http://www.ebird.org)) to collect amateur bird sightings from millions of volunteers across the world (Callaghan and Gawlik 2015; He and Wiggins 2015; Hochachka et al. 2012). This allowed Cornell to ask specific questions pertaining to the observed birds, delivering data needed to support research objectives of its ornithology program (Bonney et al. 2009). Upon observing birds in the wild, eBird participants are asked to fill out pre-specified fields; e.g.; select the biological species of the observed bird from a set of available options, and indicate how many birds of the species were observed, as well as where and when the observation took place. eBird's success relies on a large and well-established birding community.

Projects similar to eBird are common. User-generated content is becoming a major driver of community management and public policy (Johnson 2014; Maisonneuve et al. 2010). For example, CitySourced.com is a US-based project where citizens can report crime, graffiti, potholes, broken street lights and other civic issues. Other major projects include FixMyStreet in the UK (Madduri 2015), Fix-o-Gram in Australia (Foth et al. 2011), Unortkataster Koln and KA-Feedbackin in Germany (Gürder 2013), Ushahidi (originally based in Kenya, now a global project) (Gao et al. 2011) and Nericell in India (Mohan et al. 2008). In healthcare, hospitals, governments and other agencies foster health-related UGC. A major project of this kind is Med-Watch, run since 1993 by the US Food and Drug Administration to elicit adverse reactions and quality reports associated with drugs and medical devices (Craigle 2007; Kessler et al. 1993).

Another important application of UGC is in scientific research. Scientists actively seek contributions from ordinary people (citizen science). Citizen scientists participate in a diverse range of online projects, such as folding proteins, describing ocean floors, classifying galaxies, deciphering ancient scripts and identifying species (Bonney et al. 2014; Goodchild 2015; Hand 2010; Prestopnik and Tang 2015; Stevens et al. 2014). Citizen science promises to reduce research costs and has led to discoveries (Lintott et al. 2009). In the biology domain alone, it is estimated that up to 2.28 million people are engaged in major citizen science projects contributing over \$2 billion of in-kind value (Theobald et al. 2015).

## 1.1 User-generated content and Participatory Design

Despite high-profile successes; e.g.; Twitter, Facebook; and clear readiness and enthusiasm of people to produce online content, UGC's promises for organizations have been slow to materialize. Organizations remain skeptical when it comes to using UGC for internal decision making and operations (Brabham 2013; Kilian 2008; Lewandowski and Specht 2015; Prpić et al. 2015; Rossiter et al. 2015; Singer et al. 2011). Prior research identified persistent concerns about the quality of information produced by ordinary people as a key adoption barrier (Allahbakhsh et al. 2013; Gura 2013; Ipeirotis et al. 2010; Lewandowski and Specht 2015; Lukyanenko and Parsons 2015; Wiggins et al. 2011). This is unsurprising, given that in open online settings (in contrast to traditional corporate information production), little is known about the context in

which data is produced, as well as the qualities, qualifications and motivations of the individual producer.

Given that UGC can be collected from millions of online users, the vast majority cannot be directly involved in the design of these systems. No established principles for designing systems to collect UGC exist (Lukyanenko and Parsons 2012). Many UGC systems suffer from poor usability (Jones and Weber 2012; Kleek et al. 2011; Newman et al. 2010; Stevenson et al. 2003), and users often have to resort to workarounds to report what they deem to be valuable (for the organizations) (Lukyanenko et al. 2016). Such solutions cannot be expected of every user, considering the many motivations and levels of computer/information literacy in these settings (Coleman et al. 2009; Nov et al. 2014). Inadequate consideration of users' views, resulting from poor user involvement during system development, has a negative impact on user engagement (Attfield et al. 2011; Ferrari et al. 2011; Kleek et al. 2011; Lukyanenko et al. 2014b). Limitations imposed on system design also affect information quality—the quality of data users contribute via the systems (Bonney et al. 2009; Lukyanenko et al. 2014a; Wiggins et al. 2011). Hagen and Robertson (2010, p. 39) warn that “when participation is not at the core of the development of participatory systems”; i.e.; systems premised on high online user engagement, such as our kinds of UGC), projects risk failure not only due to user abandonment, but they may also engender serious privacy and security violations and may even compromise users' physical safety.

Growing evidence from case studies of UGC converges on the need for more effective involvement of people who contribute UGC in development; researchers also consistently report lack of established principles for doing so (Chen et al. 2011; Lukyanenko 2014; Newman et al. 2010; Parfitt 2013; Prestopnik and Crowston 2012a). This motivates the question of how to effectively engage online users in the development and design of systems that harness UGC to better realize the potential of these projects and improve user experiences when creating data. We argue this question can be answered by expanding concepts in participatory design (PD), which potentially can improve the usability of these systems and result in greater user engagement and satisfaction with the systems. As accurately incorporating user views has been shown critical to IQ (Lee et al. 2006; Levitin and Redman 1995; Strong and Volkoff 2010), we further expect PD to improve the quality of UGC and pave the way to its wider adoption in decision making and operations by organizations. Furthermore, as PD sees users as equal design partners, effectively harnessing the enthusiasm and creativity of people can not only improve the design itself, but also holds potential to generate new design visions, pose novel questions and find creative solutions (Löwgren and Stolterman 2004; Sanders and Stappers 2008)—all valuable properties in the new and uncharted sociotechnological landscape of UGC.

Participatory design has a long tradition, but transferring its knowledge and practices to UGC is not straightforward. Participative challenges in UGC differ from those in traditional (internal, organizational settings) and in other distributed, multi-user settings; e.g.; open source software, multi-party systems. At the same time, UGC is an interesting emerging domain, and exploring PD in this context may generate novel insights and contribute to knowledge and practices in PD itself. In this paper, we analyze the challenges and opportunities associated with PD in organization-directed UGC development, illustrate these with two UGC projects, and propose fruitful directions for future research.

## 2 Seeking solutions in Participatory Design

Since the 1970s, researchers in Scandinavia and the United Kingdom have advocated a cooperative approach to IS development, which became known as ‘participatory design’ (Bodker 1996; Ehn 1988; Iivari and Iivari 2011; Kraft and Bansler 1994; Kujala 2003; Kyng 1991; Mumford and Henshall 1979). Participatory design aims to involve users in system development, giving them influence over design choices of the system they are to use. Concomitantly, user involvement fosters mutual learning between designers and users, informing “all participants’ capacities to envisage future technologies and the practices in which they can be embedded” (Robertson and Simonsen 2012a, p. 3). Unlike other forms of human-centered design; e.g.; user-centered design in which users’ role is to provide design input; PD sees users as equal partners in the development process, in which users generate design ideas, and often make final design decisions (Löwgren and Stolterman 2004; Sanders and Stappers 2008).

As central concerns in UGC include improving the quality of information provided by non-expert contributors and creating usable and enjoyable online communities, PD appears to be well-suited for supporting these objectives. At the same time, UGC presents novel challenges for participation and conducting participatory design. UGC systems possess characteristics of both organizational IS (the traditional objects of inquiry of PD), as well as social media, online systems and user-generated content systems, (which are relatively new to PD). This makes it difficult to apply established principles and practices of PD to UGC.

### 2.1 Organizational Participatory Design

The PD tradition was born in organizational contexts (Bjerknes and Bratteteig 1995; Bodker 1996; Kyng 2010; Markus and Mao 2004; Shapiro 2010), in which research and practice formed a set of practices for fostering user participation and mutual learning. These practices are particularly effective when users and developers are in close (physical) proximity and developers can engage users in direct and long-lasting dialogs (Gumm 2006; Wubishet et al. 2013).

Unlike in closed organizational settings with paid employees and experts, data production in UGC projects may be open to anyone and is often completely voluntary. This results in users who have varying levels of motivation and domain expertise. To remove participation barriers, registration may be optional and anonymous. As a result, characteristics of data contributors can be largely unknown. This makes it difficult to identify and recruit people for PD, and also ensure that all relevant perspectives are represented and the conflicts in domain views are considered and mitigated. As a principal objective of UGC projects is to support organizational decision making or operations, an important concern is ensuring that the resulting design features support organizational objectives, such as having high IQ. Often this means the power to make design decisions, including creating design choices and selecting among choices (Bratteteig and Wagner 2012, 2014a), lies within the organization; e.g.; scientists on eBird.org; and not with the content producers; i.e.; amateur bird watchers). This creates the potential for marginalizing data contributors and gives rise to the question of how to mitigate conflicts and strike an appropriate balance.

## 2.2 Distributed Participatory Design

More recent PD research considers non-organizational contexts and thus holds additional promise for UGC. As IS development increasingly occurs in the context of large, heterogeneous, and distributed organizations, and sometimes happens entirely online; e.g.; open source software; traditional notions of PD may not apply. One area of interest has been projects that involve large groups of people (Hekkala et al. 2008; Hirschheim et al. 2007). An organization and even developers may be distributed across different geographic locations and transcend cultures, languages, or political boundaries. These non-organizational contexts suggest the need to consider 'distributed PD' (Gumm 2006; Lings et al. 2006; Loebbecke and Powell 2009; Naghsh et al. 2008; Obendorf et al. 2009). A special type of distributed environment occurs when systems are created online, particularly in open source software communities (Raymond 2001; Stewart and Gosain 2006). Other example includes telemedicine, where doctors and patients to interact remotely via online technologies (Grönvall and Kyng 2011; Li et al. 2006). Distributed settings bring novel challenges related to communication, knowledge sharing, coordination, representation and conflict management of the different views, perspectives and goals—all issues that exist in UGC settings as well.

The challenges of PD in distributed settings have generated a growing number of innovative solutions, including increased interaction and feedback, providing intensive user support, creating interactive prototypes, and leveraging virtual meeting and collaboration technologies (Gumm et al. 2006; Lings et al. 2006; Rajanen et al. 2011; Titlestad et al. 2009). When user groups are particularly large and dispersed, developers can seek aggregate feedback through online surveys (Gumm et al. 2006) or even create virtual governments (Hess et al. 2008).

UGC shares several similarities with distributed PD. For example, in The Global Fund for Women project, major IS infrastructure included a database that stores funding applications; the classification system; i.e.; conceptual model) for the database was iteratively co-developed with regional groups (Trigg and Ishimaru 2013). Involving regional groups enabled discovering of new categories, refining existing categories and reaching common understanding on their meaning and application across the global organization spanning 174 countries. Key design decisions in a UGC project such as eBird include: conceptual structures used to capture objects of interest to scientists, but observed by the amateurs; the database schema used for storage; data collection interfaces; and other forms and processes (citation). Thus, lessons from The Global Fund for Women project may be applicable to eBird as well.

At the same time, as in The Global Fund for Women, much of research on distributed PD tends been conducted “in a professional context in organizations or with expert teams” (Näkki and Koskela-Huotari 2012, p. 134). In these settings, users are relatively homogeneous in their interests and practices; e.g.; software developers. Geographic and cultural distance can be bridged using well-articulated project objectives, virtual meeting technologies, frequent phone calls, face-to-face workshops, frequent two-directional feedback, or smaller mobile delegate groups (Gumm et al. 2006; Lings et al. 2006; Loebbecke and Powell 2009; Obendorf et al. 2009). Distributed PD also differs from UGC, as the project objectives are not necessarily driven by such considerations as IQ.

## 2.3 Participatory Design for online social technologies and Web 2.0

Recently, PD ideas have begun to be considered in more open contexts, such as community-driven projects, where users are diverse members of the general public rather than cohesive groups of interest. Working with local communities, Ehn (2008) and Björgvinsson et al. (2012a, 2012b) advanced the concept of ‘design things’, defined as designing new socio-economic infrastructures where ideas on promoting common well-being and social innovation are being constructively exchanged with the help of technology. In this context, they argued “PD faces considerable challenges”, as there is “a movement away from design projects and towards processes and strategies of aligning different contexts and their representatives, where differences between current issues and how the future can unfold can be made visible, performed and debated as a kind of ‘antagonism’” (Björgvinsson et al. 2012b, pp. 127–128). Projects that embrace this philosophy include Malmö Living Labs (Björgvinsson et al. 2012a, 2012b), Neighborhood Networks (DiSalvo et al. 2009), Australian youth safety (Collin and Swist 2016), and European Network of Living Labs (Emilson et al. 2014). These projects can be characterized as being intensely driven by local participants, where not only design, but also the project objectives themselves are subject to debate. Both project objectives and design solutions organically evolve as participants bring their own, often different, perspectives into a common mix. Fostering mutual learning, engaging people in debate, and providing technical infrastructure for this, are seen as key outcomes (Björgvinsson et al. 2012b; Emilson et al. 2014; Karasti 2014; Marttila et al. 2014; Monteiro et al. 2013). As DiSalvo and DiSalvo (2014) explain, “rather than the end goal being the design of an operational system, the end goal is an experience or event that develops the agency of participants” (p. 795).

Researchers also now investigate PD in the context of social media, forums, blogs and other content-producing systems termed social technologies (Hagen and Robertson 2010). In engaging participants in development, projects have attempted to design content producing and sharing to better promote the advantage of the openness, interactivity, collaboration, immediacy and connectedness of these tools (Näkki and Koskela-Huotari 2012; Schuff et al. 2010). Among PD approaches, prototyping, continuous close interaction with users, and continuous improvement have been suggested, but the research also notes the challenges of conducting PD in these settings (Carroll et al. 2015; Clement et al. 2008; Le Dantec et al. 2015; Salgado and Galanakis 2014).

The notions of design things, community projects, social technologies and social innovation overlap considerably with our UGC context. Projects that harness UGC inherently deal with members of general public, are often open to everyone, and are predicated on effective participation and engagement of diverse stakeholders. Also, as we show below, these projects frequently face ill-defined objectives, and continuously evolve as they embrace input from people. The projects also result in similar infrastructuring where people join together in discussion and debate. What makes organization-driven UGC different, however, is the pronounced organizational component as organizational actors hope to harness the public sphere for the organization’s betterment. Further, many UGC projects are global in scale (unlike local community-driven projects).

## **2.4 Participatory Design for organization-driven UGC**

Finally, recent work began to consider PD in our context of organization-driven UGC, including when projects support the public good. While there are no general approaches for how to conduct PD in this setting, research acknowledges the need to involve users in the design and the decision making (Bonney et al. 2009; Wiggins et al. 2013). Thus, Stevens et al. (2014) when facing the challenge of designing a monitoring app to be used by aboriginal people, advocated living with them to involve them in PD. This idea is echoed by Cottmann-Fields et al. (2013), who call on designers to immerse themselves into a bird watching experience to create more effective designs. Jay et al. (2016) suggested (when developing a website that enlists volunteers to digitize Manchester Museum's fossil collection) to leverage curation staff at the Manchester Museum for initial development and then test and refine with "a convenience sample of people who had not used the app before" (p. 2). Relying on project owners for design input and design decisions appears to be a popular emerging PD strategy (Callaghan and Gawlik 2015; Sullivan et al. 2009). Below, we show that we followed the same process in one of our projects; i.e.; NatureWatch, Phase 1; and raise questions about the implications of this strategy for PD. The emerging research in the context of organizational UGC underscores the importance of this domain, but also demonstrates the lack of established PD principles and may advocate strategies that are potentially problematic for PD (discussed later).

As we demonstrate below, this organizational element brings its own challenges that not only require different solutions, but raise broader questions about the role of PD. Referring to a broad context of Web 2.0 applications where users can create own content, Clement et al. (2008) note, "there has yet to be much in the way of PD-informed research into what participatory design may mean in this context and how to conduct it" (p. 51; emphasis added). Considering increased interest to community-driven, open contexts, DiSalvo and DiSalvo (2014) call for more research into how to apply PD to these settings: "new practices of participatory design are challenging to the participatory design community" (p. 795).

Participative design in UGC is an increasingly important, but not yet fully understood, addition to the PD landscape. In the next section we present case studies of two real UGC projects. We use the cases to analyze key features of UGC and contrast them to both traditional and emerging streams of PD to establish the unique position of UGC in the broader context of PD tradition.

## **3 Case study of two UGC projects**

As seen from the review of previous research on PD, UGC settings exhibit both similarities and differences with respect to prior contexts in which PD has been studied. To better understand the unique challenges of UGC, we draw on case studies of two real-world projects. Our two cases, NatureWatch and WeatherRecorder (both fictitious names of real projects), exemplify a specific form of UGC under the umbrella of citizen science. Citizen science describes projects wherein people from all walks of life participate in some aspect of scientific research (Silvertown 2009). With advances in web-based and mobile computing technology, citizen scientists

now engage broadly in research activities online. Such activities include supplying data (as with eBird, described above), processing data; e.g.; identifying and classifying objects in photographs, as in GalaxyZoo; or transcribing data; e.g.; translating handwriting to digital text, as in OldWeather; (Eveleigh et al. 2013; Lintott et al. 2008; Sullivan et al. 2009). The level of engagement by project sponsors with data contributors varies across citizen science projects, thus offering a rich array of cases to explore issues of PD and UGC. From a PD researcher's point of view, an important advantage of citizen science as a research context is its public domain nature—allowing us to peek into the development process and examine and report PD issues without being constrained by commercial secrecy and profit-motivated proprietary methods and techniques.

### 3.1 Method

The description and analysis of the cases is based on participant observation, interviews and reflection on the authors' own roles in the projects. Table 1 provides a summary of the cases. A case study methodology is particularly effective for illuminating complex emerging phenomena in their original context (Baxter and Jack 2008; Yin 2013). Participant observation provides an intimate perspective on the projects. At the same time, not all authors were involved in both projects and, of those involved, some were engaged indirectly. This creates some distance and contributes to impartiality and objectivity of the presented cases. Specifically, four of the five authors of this paper have been involved in NatureWatch from the beginning (2009) to varying degrees. One author was the principal investigator of the project and its sponsor; another worked as a principal developer; two other authors were less involved: one represented the larger Canada-wide initiative and the other provided general IS expertise. Only one of the authors was involved in the development of WeatherRecorder (as a social scientist and expert on PD in UGC), but only since the second phase (below). Finally, one of the five authors was not involved in either of the projects.

For both projects we describe PD activities; e.g.; prototypes and co-development workshops; but also report on other relevant user-centered activities; e.g.; experiments; and design decisions; e.g.; flexible database design; (see Table 1) to present evidence for the analysis of challenges of conducting UGC in PD.

### 3.2 Case 1: NatureWatch (2009 – present)

The NatureWatch project was launched in 2009 at a Canadian University, as part of a larger Canada-wide initiative to investigate how to engage the general public with issues of environmental change by means of interactive communication technologies. The specific scientific objective of NatureWatch is to map biodiversity in Newfoundland and Labrador—a region in Canada of over 150,000 square kilometers—based on sightings plants, animals and other natural phenomena by online volunteers.

When the project started in 2009, the project's principal investigator did not have a well-defined biological research question to be answered through citizen scientist contributions. Instead, the main motivation was to investigate how people would participate in an online UGC

|  | <i>NatureWatch</i>   | <i>WeatherRecorder</i>   |
|--|--|--|
| <i>Sponsoring organization</i>   | A research group within a university   | An interdisciplinary team  |
| <i>Nature of evidence</i>  | Reflection on past experiences in PD   | Reflection on past and current experiences in PD   |
| <i>Project Timeline</i>  | 2009-Present;<br>2 major phases  | 2010-Present;<br>2 major phases; Currently in development  |
| <i>Scientific objective</i>  | Mapping biodiversity in a region of Canada   | Transcribing hand-written weather records in Canada  |
| <i>Objects of interest</i>   | Any sighting of plants, animals, and other phenomena; e.g.; interesting rocks, landmarks.  | Daily temperature, precipitation, wind speed and direction, humidity, pressure, cloud layers and coverage  |
| <i>Target data contributors</i>  | Any resident or visitor to the region (no age restriction)   | Anyone willing to transcribe, although focus is on current and former residents of city  |
| <i>Data consumers</i>  | Scientists, government conservation agencies, local tourism industry, environmental NGOs   | Scientists, librarians/archivists  |
| <i>Activities and approaches (including PD) explored at various project phases</i> | Co-development with users<br>Continuous usability studies<br>Discussion boards for design feedback<br>Lab and field experiments (N>500)<br>Workshops, interviews, meetings with existing and prospective users<br>Pen and pencil, realistic prototypes<br>Flexible user interface and database design<br>Continuous improvement based on user feedback | Loosely-coupled systems (Google groups, Dropbox, Picasa, spreadsheets)<br>Merging of developers, data consumers and data contributors<br>Leveraging power users to develop training and instructions<br>Discussion boards for training and feedback<br>Breaking tasks into smaller units<br>Making contribution process exciting and enjoyable |

Table 1. The two citizen science projects at a glance.

project, create data and to compare it to other projects across the country. The focus was to explore whether participation was concentrated in parts of the region or within certain demographic groups; i.e.; digital divide; and to investigate how people engaged with the site; e.g.; contribute new data, comment on other participants' sightings, visit the site to look at data/maps. The interface was designed to be open-ended; e.g.; lean registration form, optional demographic questions, photos; but it emphasized a traditional biological focus—recording observations of biological species. To post a sighting, users had to indicate the biological species observed. Fol-

lowing the second phase, the requirement to classify species was dropped and participants could simply list a sighting as “unknown” and describe it through an open-ended form. These design decisions were deliberate, but meant that data collected did not meet the standards necessary to be useful in scientific research. For example, there were no set sampling protocols, nor were people asked to provide details on their surveying efforts. We also did not require people to list everything they had sighted; the choice of what to contribute and how often was left entirely up to the data contributors.

Throughout the development, a number of PD strategies were suggested for both traditional and distributed settings. The design of the project was highly participatory with intense user involvement, but proceeded through two phases, characterized by differences in the underlying design philosophy and power to make design choices and select among them (Bratteteig and Wagner 2012). In the first phase (2009-May 2013), scientists were the users who dictated most design choices, whereas in the second stage (May 2013 - Present) design choices were shared more with citizens.

In the first phase, no established principles for developing these projects existed (Lukyanenko and Parsons 2012). Consequently, the project was developed using a traditional approach, in which data was collected based on the units of analysis of interest to scientists - the project sponsors and prospective consumers of the resulting data. Consistent with work on information quality, Phase 1 development was consumer-driven as project hoped to deliver high quality data for data consumers (Wang and Strong 1996). Projects’ objectives, vision, key subject matter expertise, specifications and most operational design decisions (Löwgren and Stolterman 2004) (including focusing on biological species as the level of analysis) came from a small group of users - the biologists. This also fit the intuition of the development team: we argued that since citizen scientists could be non-experts and the data was needed by the scientists, PD should be scientist-driven. This was also consistent with cases of similar development reported in literature (Prestopnik and Crowston 2012b; Sullivan et al. 2009). Physically, the development occurred in a biology lab with constant interaction with scientists, who became co-developers. Graduate students in biology were also consulted for user interface decisions, usability, and initial testing.

Once most of the design features were in place, workshops were conducted with citizen scientists to both promote the project and seek last-minute confirmation and refinement of the designs (Bratteteig and Wagner 2012, 2014a; Tremblay et al. 2010). The project also was presented to the team members of the other nodes of the Canada-wide initiative who provided additional usability expertise. After the Phase 1 design was finalized, an online discussion board was created (Gumm et al. 2006; Näkki and Koskela-Huotari 2012) where citizen scientists were asked to report design flaws and issues and suggest potential improvements. Those suggestions deemed reasonable by scientists were implemented.

An evaluation phase began as soon as the project was launched and revealed limitations and negative consequences of approaching citizen science by focusing on the data consumers. For example, consider a person who is not a biology expert hiking along a coastline who observes a peculiar bird and wishes to contribute the sighting to NatureWatch. From the user’s perspective, the best description of the observed instance might be ‘large white bird covered in oil’. This reflects the level of classification the non-expert is able to provide (bird) and relays important attributes that might aid in identification at a more specific level (large and white), as well as an attribute indicating exposure of the animal to anthropogenic disturbance. The data entry

interface of the project, however, assumed that the species observed was known and required classification at the species level. The interface also ignored attributes of the instance that were not anticipated. In this case, a contributor may choose to guess the species (and possibly be incorrect) or abandon data entry. Even in the case of a correct guess, the potentially valuable attribute 'covered in oil' would be lost (or, if, entered as a text comment, escape structured storage and likely go unnoticed in analysis). Facing incongruent choices, the citizen scientist may even develop negative attitudes towards NatureWatch and possibly the organization that sponsored it. Alternatively, he/she might feel inadequate and even avoid participating in citizen science projects in the future. Analysis of NatureWatch's logs, comments and forum posts offered plenty of evidence of the issues described above.

In principle, had designers engaged the same person in PD and built the system based on this user's input, the user might have been able to successfully record the sighting of a "large white bird covered in oil". In reality, however, this is not plausible, both because, in open UGC settings, developers do not know who the participants will be and, even if all participants are identified, the open-ended domain would preclude developers from discovering idiosyncratic user conceptualizations; e.g.; a large, white, oiled bird.

Based on this analysis, a more formal evaluation of the project was conducted. This included a series of laboratory and field experiments, engaging over 500 non-experts. In the experiments, several design alternatives were proposed. We showed participants images of local plants and animals and asked them to simulate data reporting first using paper and pencil versions of interfaces (Kyng 1995) and, later, functional online prototypes (Dey et al. 2001). The experiments provided strong evidence of the extreme diversity of user views; i.e.; no two descriptions of any item by different people were exactly the same. Through these experiments, we confirmed that conducting PD that privileges scientists, without fully considering other users (citizens), can lead to lower accuracy of reported information, loss of unanticipated information and lower user engagement. Users whose situational or individual perspectives are insufficiently represented in the IS may find it difficult or impossible to contribute information and will generally participate less in the project.

Motivated by these findings, but also facing lack of theoretical guidance on how to effectively conduct PD in these settings, the project was redesigned as more open-ended and citizen-driven. Specifically, an instance-based approach to data collection and database storage was implemented (Parsons and Wand 2000), rather than the prevailing relational (Codd 1982) database design. This meant that data collection was no longer driven by the conceptual structures of interest to data consumers; i.e.; biological species. Instead, citizens could describe the observed phenomena using any number of classification labels and attributes.

In addition to the change in the modeling philosophy, preceding the launch of the Phase 2 website one of the paper's authors toured the region to promote the website and seek last-minute design guidance from significantly wider (than in Phase 1) audiences. During a week-long, 3000 km trip, 60 informal and 5 formal meetings and presentations were held with citizens. The new design philosophy was generally well-received as the citizens appreciated the novel ability to report information the way they perceived it. With the launch of the new version and following the tour, the site saw a marked increase in the number of people signing up for the website. At its peak the site had 30,000 visitors per quarter in mid-summer 2013 (Figure 1)—a considerable success for a regional project.

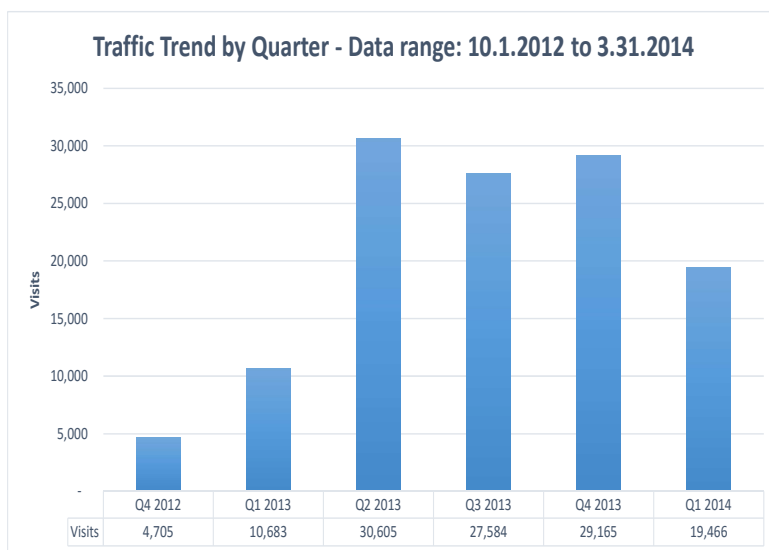


Figure 1. Traffic trend on NatureWatch before and after the launch of Phase 2 (Q2 2013).

From a biological research perspective, however, the design decisions implemented in Phase 2 have meant that the data, in its raw form, is not always usable for helping answer traditional biological research questions. While usability improved from the data contributor perspective, the needs of the data consumers are not directly satisfied (as in Phase 1).

### 3.3 Case 2: WeatherRecorder (2010-present)

WeatherRecorder was launched in 2010 by an independent researcher in Canada. The project later attracted an interdisciplinary team. The purpose of WeatherRecorder was to crowdsource the transcription of hand-written ledgers on which Canadian weather data was originally collected, with the goal of enhancing information available to climate scientists. In 2014, the project was adopted as part of a large pan-Canadian university grant (different from the initiative mentioned in Case 1) to explore how citizen engagement via interactive mapping technologies was transforming urban governance. The specific scientific objectives of WeatherRecorder are: to preserve old weather records originally in handwritten form, to create an opportunity for volunteers to participate in science, and to provide data for atmospheric and climate scientists. Further details about the project can be found above in Table 1.

While NatureWatch follows a category of citizen science in which volunteers are asked to contribute original observations, WeatherRecorder engages volunteers in interpreting existing data to render it usable for research purposes. WeatherRecorder resembles a popular project, Old Weather, where data processing takes the form of “digitizing” versions of old records, in this case, volunteers transcribing sailing ships’ logbooks (Eveleigh et al. 2013; Morais and Santos 2015). WeatherRecorder differs from the other weather-related citizen science projects; e.g.; Old Weather, Weather Detective; in its diversity of logbook formats and multiplicity of environmen-

Figure 2. An example of a single ledger sheet.

tal parameters. WeatherRecorder data exists in 15 different ledger formats, stretching from the 1870s to the 1950s.

In Phase 1 (2010), one person functioned as both a developer and a consumer of the data. Volunteers were recruited from bulletins of the Canadian Meteorological and Oceanographic Society, assorted climate blogs, and professional articles, resulting in a small and relatively homogeneous group of users—all data consumers and all experts. No specific application was built. Instead the developer and data contributors employed a combination of existing yet separate tools to create a loosely coupled system. Scanned logbook sheets were uploaded to Dropbox along with spreadsheet templates. Volunteers would digitize specific books of sheets.

Data contributors (in this case, weather enthusiasts and scientists) were extensively involved in shaping the loosely coupled system. Scanned images of the handwritten documents were occasionally difficult to discern because of the quality of the microfilm (Figure 2). More importantly, the original weather observers possessed their own shortcuts, weather vocabulary and symbols that had no easy-to-translate current analogs. A Google Group was created so contributors could post screenshots of illegible handwriting, discuss historical weather vocabulary (where occasionally French terms were substituted for English terms), and exchange tips. One volunteer also hosted a Picasa page on which confusing entries could be compared and discussed. For one such entry, a contributor commented that the entry “is so faded that none of my tricks in a photo editor seem to bring up any more clearly what the text is (beside the temperature “60”, above the wind SW ~)... I guessed at SE light, highlighting this cell in my spreadsheet for additional interpretation.” Despite these complexities, nearly one million observations were digitized and then used to report on climate variations of over 200 years.

The success of the Phase 1 project led to the evolution of the project objectives. Phase 2 (on-going) shifted from a single developer to an interdisciplinary team, consisting of atmospheric scientists, librarians, archivists, IS scholars, a geographer, and a citizen science specialist. The goal shifted from the singular provision of data for atmospheric and climate scientists to include the preservation of historical weather records and the creation of a single interactive citizen science platform to enhance the citizen scientist experience. The project team began building the system, forking the popular citizen science platform, Zooniverse ([www.zooniverse.org](http://www.zooniverse.org)), which allows the project to engage millions of people.

The interdisciplinary team brought multiple objectives to the project. Phase 2 broadened the developer, consumer and contributor base. Now the archivists view the project as a mechanism and funding to transform the media of the original ledger data. The ledgers were microfilmed in the 1970s; new funding streams meant that pages could be reviewed and rescanned. Librarians see the project as an opportunity to promote the importance of curation and other library assistance in citizen science endeavors. Some team members are interested in the process of citizen science; e.g.; user motivations and satisfaction, and data accuracy. Indeed for some data consumers, the ultimate goal is not the transcribed data at all. This can translate into muddled goals spreading to the system itself. A prime predictor of failure of citizen science projects is a lack of clearly articulated goals (Dickinson et al. 2012).

In Phase 2, two methods to improve quality are currently being investigated. Zooniverse supports an “upvoting system” where three or more volunteers transcribe the same dataset. Entries that achieve consistency among two or more contributors are considered valid. The team also is developing training materials. Developing training material, like data entry protocols or videos, has been found to enhance quality, especially when it emphasizes common challenges and frequently asked questions (FAQs) of users (Bonney et al. 2009; Gommerman and Monroe 2012).

Phase 2 also benefits from prior users’ reflections on the challenges of transcription. Past users were essential to developing training material for future users. These were high level “power” users, as evinced by the sheer number of observations transcribed. Part of the training material includes a FAQ section that uses and expands upon the content provided by the original transcribers. We also will provide an online forum for additional training and support.

Protocols for recently joined data contributors are being established because team members are concerned that new users may not be as enthusiastic as those in Phase 1. Phase 1 was highly participative as the developer worked closely with volunteers who possessed a stronger connection to the field. For example, one dedicated contributor became the go-to expert on interpreting minus signs. Phase 2 anticipates opening the project to a broader population of citizens worldwide to participate, so data contributors likely will be more distant from the subject matter. More emphasis is being placed on a user interface that offers an enjoyable experience. In Phase 1, the user interface was basically ‘take an entire microfilm and enter it into the spreadsheet.’ In Phase 2, the team is investigating how to turn the data entry into micro tasks, where volunteers can focus on adding a record at one time, instead of a page at a time. As the project is still in the development phase, there are no results to report and the team is still debating the best approach to attain contrasting objectives in the project, generating high quality data while keeping online contributors engaged and excited. The team also has concerns of how to scale up PD with a million-strong user base.

### 3.4 Summary of both cases

As seen from both cases, opening organizations to UGC can be quite beneficial, promising additional human resources and new sources of insights. However, due to the differences between UGC and traditional organizational applications, it is unclear how to conduct PD for such systems. Table 1 summarizes several PD approaches explored in both projects. Notably these have been suggested both in traditional and emerging PD contexts, but the effectiveness and usability of the systems is inconclusive based in our two projects. Both projects went through phases of development discovering and reacting to limitations of previous approaches, but not fully knowing how to address them effectively. For example, whereas NatureWatch's Phase 2 appeared to have improved usability for data contributors compared to Phase 1; it came to some degree at the expense of the project's core objective (scientifically useful data).

In contrast to more traditional settings, where users are known in advance and can be effectively engaged in development, both projects are unsure of how to engage anonymous and diverse audiences in design. Very little of the interface in the WeatherRecorder's Phase 1 project (when users were small and homogeneous) is currently preserved in Phase 2 when the project is opened to diverse online contributors. In both projects, it is unrealistic to know every single participant, every object of observation, every way an observer might conceptualize these objects and interface options that would work best for each instance of data creation. Nonetheless, failing to consider user views when making design choices threatens the success of these projects (Lukyanenko et al. 2014a).

Building on the conceptual arguments and the empirical evidence, in the next section we analyze the challenges of PD in UGC and propose research directions for future studies.

## 4 Participatory Design challenges in UGC development and directions for the future

As no generally-accepted approach to PD in UGC exists, how to conduct PD in UGC settings remains an open issue. We return to the evidence from the two cases above in light of existing research to identify specific characteristics of UGC that create novel challenges for PD and suggest research directions based on these challenges.

### 4.1 Establishing benefits of PD for UGC-based IS development.

Research has uncovered many advantages of PD, but these have been studied in a variety of contexts, including corporate, open source software, and local community settings (Bjerknes and Bratteteig 1995; Gumm et al. 2006; Markus and Mao 2004; Simonsen and Robertson 2012). Intuitively, benefits of PD continue to be germane to the UGC context, the question still arises:

*What are the core benefits of PD in UGC projects?*

Software development within organizational settings commonly relies on the availability of employees, whose identity and organizational role is generally known to developers. In contrast, a common feature of UGC is unconstrained, voluntary and largely anonymous participation. As Wiggins and Crowston (2011) note “open participation [is] nearly universal” across projects (p. 1). ‘Everyone is welcome to join’ is a common slogan (Brown et al. 2010), as projects may attract millions of people across the globe (Hochachka et al. 2012). Compared to a traditional corporate scenario, open and anonymous UGC settings provide little ability to determine who are the potential data contributors, and how to reach them effectively, how to engage them in design decision making. In this context, several interesting issues emerge.

Traditionally, among other things, developers turn to users for domain expertise (Land and Hirschheim 1983; Robertson and Simonsen 2012b). In UGC, however, contributors often lack deep subject matter expertise (Coleman et al. 2009). For example, on the NatureWatch project, naturalists are in proximity to birds (making them highly valuable to the organizational sponsors), but may not know how to tell birds apart or what to look for in reporting information (see also Hochachka et al. 2012; Wiersma 2010). A dilemma of UGC is that a given participant might be a valuable data contributor, but at the same time an unreliable source of domain expertise. The role of non-expert users as domain knowledge providers appears quite different in UGC settings. Does this suggest, for example, that one should focus on eliciting certain design choices, but not others, and focus less on asking users to confirm or decide on them? Here, existing work on PD with children and impaired users appears quite germane (Bratteteig and Wagner 2014a; Ruland et al. 2008).

Similarly, users involved in design can no longer be expected to return to their organizational units and disseminate the information and sentiments about the new system. Furthermore, the act of voluntary creation of information to advance organizational objectives (that here are public goods) also stands to foster “the agency of participants” (DiSalvo and DiSalvo 2014, p. 795) and empower participants (Aceves-Bueno et al. 2015; Evans et al. 2005; Reed 2008). In both projects, participants formed communities around the projects, and many became intimately involved in the role of project advocates. This raises the question:

*How can the sense of involvement and empowerment experienced by the UGC contributors engaged in development be disseminated across a larger (often anonymous) community in the absence of direct user-to-user contact?*

We assume much of this communication will be in the virtual, rather than physical space, which leads to an intriguing question. We know that electronic word of mouth can shape public opinion online, but so far studies have focused on promotion of products or ideas (Oh et al. 2016; Schuff et al. 2010; Zhang et al. 2013). What we do not know is:

*How reliable is electronic word of mouth for shaping user perception of the usability of the system and spreading the excitement and empowerment accrued as a result of user involvement in design?*

At the same time, research may uncover novel advantages of PD. Research on PD has consistently argued that harnessing the enthusiasm and creativity of people can not only improve the design itself, but also holds potential to generate new design visions, pose novel questions and find creative solutions, and empower participants (Löwgren and Stolterman 2004; Sanders and

Stappers 2008; Sieber 2006). Since UGC experiments with novel socio-technological forms and engages large groups of people, it may become a fertile ground for testing this thesis. UGC is a novel type of information with uncertain potential. Frequently, projects are conducted in hypothesis-free manner (Wiersma 2010). Projects are commonly multi-objective, as was the case for both NatureWatch and WeatherRecorder. When developing NatureWatch, for example, users contributed to the understanding of the limitations of established approaches to IS development, which resulted in a dramatic rethinking by the development team of the valid technological spaces for UGC. Thus, we had a case of effective mutual learning and creativity that is at the core of PD. Likewise, Phase 1 of the WeatherRecorder project was completely co-developed by users, leading to many novel ways to digitize weather logs proposed and implemented by users themselves in a highly decentralized manner. This, of course, occurred in the context of a small and highly homogeneous user group—making the experience non-transferable directly to Phase 2. One specific question that arises from this case is:

*Which phases of design and which design objects stand to benefit the most from user participation in UGC settings and how can these benefits be realized in open anonymous settings?*

## 4.2 Leveraging PD in satisfying organizational information needs.

Whereas organization-led UGC is very similar to other distributed projects; e.g.; local community networks, open source software; organizations and their needs are very prominent in these projects. Consequently, projects have objectives and constraints in place to satisfy informational needs of the organizational sponsors. The objectives of both cases were relatively ill-defined; however, both had specific constraints; e.g.; observations of species, accurate transcription of logs; and these very much affected PD (potentially explaining the lopsided scientist-orientation of NatureWatch's Phase 1).

High information quality is a natural concern in projects where UGC supports scientific research, healthcare or public policy (Bonney et al. 2014; Hochachka et al. 2012; Nov et al. 2014; Show 2015). Prestopnik and Crowston (2012a, p. 9) write: “[the scientists’] primary goal is that these [projects] should produce large amounts of very high quality data. Virtually all other considerations are secondary”. Similarly, a large volume of content is required to ensure sufficient sample size for analysis and representative samples (Cha et al. 2007; Salk et al. 2015). Sustained content creation is also critical for the overall viability of online communities (Butler 2001; Nov et al. 2014). Where UGC is used to aid in rapid natural disaster response, data needs to be both accurate and timely.

Traditional research on PD does not specifically emphasize the connection between PD and information quality, sustained content production or user engagement resulting from effective application of PD. Even less is known about how to make such connections in UGC settings. For example, once participation was open to diverse crowds, Phase 2 of the WeatherRecorder project had to transform the original task by chunking it into smaller micro-tasks. This decision was made intuitively, but the question arises whether citizens themselves can be engaged directly in shaping decisions about how to collect data (from themselves) to ensure its quality for organ-

izations (and maybe even what data to collect). This, of course, appears to require citizen knowledge of the organization, its data needs and data processes—something that may be difficult for non-experts to comprehend and, perhaps, even too proprietary for organizations to disclose.

*More research is needed to increase our understanding of the role of PD in shaping information quality and content creation in UGC projects.*

Such general understanding can then inform specific PD activities and methods that developers can leverage to increase quality and improve content production in the projects.

### 4.3 Coping with conflicts and power to make decisions in UGC.

Unlike many free open source projects that have flat or weak organizational structures (Seifu and Tsiavos 2010; Wubishet et al. 2013), UGC projects have an implicit hierarchy rooted in the organizational context in which these projects originate. Thus, scientists are subject-matter experts who use the data created by non-experts to further organizational goals. The role of consumers and contributors may overlap; that is, scientists can be data contributors as well, but often, these groups have different objectives and may not share domain views. This creates potential for conflicts during and after development, and introduces additional challenges to PD activities; e.g.; how to balance their views and which group to focus on. UGC provides a novel context for the ongoing research on power and decision making (Bratteteig and Wagner 2012, 2014a).

For example, NatureWatch's Phase 1 was highly participative (even moving development to the biology lab) but was very driven by scientists—who shaped the initial project's vision (Löwgren and Stolterman 2004) and chose among the specifications they helped to co-create. Ordinary citizens were consulted, and to some extent made design decisions, but their role was mainly confirmatory and, compared to scientists, they were marginalized in the design process. This bias toward one user group—organizational data consumers—has been reported in other UGC projects; e.g.; (Jay et al. 2016; Lukyanenko et al. 2016; Prestopnik and Crowston 2012a); due to their strong focus on delivering information for organizations to use (unlike more community-focused projects such as Living Labs (Björgvinsson et al. 2012b; Ehn 2008)). Scientists are those who need the data created by citizens, and often (as in the case of NatureWatch) scientists pay for the development of the UGC projects. Thus, Phase 1 of NatureWatch was fully participative from the point of view of scientists, but merely user-centered (Sanders and Stappers 2008) from the point of view of citizens.

An important research question is:

*How to effectively mitigate conflict and ensure meaningful decision making when there are two stable user cohorts with potentially different world views?*

The limited success of the NatureWatch's Phase 1 case, despite it being driven by scientists and not citizens, adds new evidence for the claim by Bratteteig and Wagner (2014b) “that even a process with limited—not ‘full’ user participation can result in a design that increases the ‘power to’ of users” (p. 31). At the same time, the question becomes:

*How to give more power to make design decisions (including on design choices) to citizens.*

We believe that UGC can benefit from research with similar dichotomies and power-related conflicts. For example, scientists and citizens in NatureWatch and WeatherRecorder are analogous to many other groups: doctors, journalists, urban planners, architects, open source software activists, power users; i.e.; domain experts; versus patients, non-expert content providers, novice users and citizens; i.e.; often non-experts; (Andreasen et al. 2015; Bratteteig and Wagner 2014a; Grönvall and Kyng 2011; Salgado and Galanakis 2014; Singer et al. 2011). Indeed, organizational conflicts; e.g.; disagreements on project goals, domain views; occur in traditional (Checkland and Holwell 1998) as well as distributed settings (Björgvinsson et al. 2012b; Erickson and Evaristo 2006; Hekkala et al. 2008). The solutions explored in other domains can be potentially brought into UGC. For example, one might embrace the conflict and allow for all voices to be heard and considered—an idea inspired by community-driven projects (Björgvinsson et al. 2012b; Ehn 2008) and present in some open source software (Andreasen et al. 2015; Wubishet et al. 2013). In Phase 1 of WeatherRecorder, all users were co-developers and the decentralized nature of the technologies meant that many decisions were made by users directly. This worked, however, because of the relatively small scale of the operation. As the project scales up to a million-strong user base, an immediate gap appears between the development team and the users—indeed this is when ‘power users’ emerge. Yet, expanding the user base to millions potentially means a great multitude of very creative design ideas motivating more work on ways to harness participation at scale.

#### **4.4 Who are the users? Managing user involvement in UGC**

A consequence of open and anonymous participation is extreme diversity of users; e.g.; data contributors, data consumers, other stakeholders. NatureWatch was a natural history initiative designed to attract under one umbrella anyone in the region with the interest in local environment, including tourists, aboriginal peoples, outfitters, fishers, young children, graduate students, scientists, monitoring agencies, and government officials. The WeatherRecorder’s user base was just as fragmented and complex. This is quite common for UGC (Coleman et al. 2009; Hagen and Robertson 2010; Wiggins and Crowston 2011), as organizations hope to leverage the temporal and spatial affordances of the Internet, and these projects (particularly when there are driven by public interests) open novel opportunities for the community.

One way to conceptualize user involvement is to consider it made of core users (those directly involved in the project), periphery (users and clients not actively participating) and the context (surrounding society and environment)(Löwgren and Stolterman 2004). As we saw in both projects, but especially in NatureWatch, in UGC it is extremely difficult to determine who belongs to what circle. These boundaries in UGC are not only fuzzy, but are also dynamic. Thus, in Phase 1, for example, most citizens were on the periphery, but became very central in Phase 2.

The extreme diversity of users complicates selecting representatives of each view. Whereas ‘representative user’, ‘user role’, and ‘idealized user type’ concepts have been important to PD (Dahlbom and Mathiassen 1993; Löwgren and Stolterman 2004), directly transferring this notion to UGC is problematic. Through UGC projects, organizations may engage global audienc-

es and appeal to members of the general public with no age or expertise restrictions. It is quite unclear who the user is in UGC. Indeed, one radical idea born in the context of community networks similar to UGC is to include animate objects of observation; e.g.; birds, animals; into the stakeholder; i.e.; periphery; group (Binder et al. 2015; Jönsson and Lenskjöld 2014).

In Phase 1 of WeatherRecorder, all users were engaged in development. In Phase 2, representative users for the purposes of generating training materials were defined as power users based on number of observations transcribed; however, other strategies can be pursued, such as stratifying users based on their expertise. An open question, therefore, is:

*What is the right strategy for selecting people to directly participate in design? Further, it is unclear which design features can be developed based on input from a subset of users?*

By the logic of PD, given the potential diversity of user views, projects may need to bring in every single potential user or find ways to partition the vast and diverse user space into conceptual units from which to draw representative users? Does this imply that in UGC, context and core could be the same?

## 4.5 Exploring novel approaches to IS development.

Considering the PD challenges described earlier, the question can be raised:

*Should we design IS differently to overcome some of these challenges?*

Due to the dramatic differences in user views, many existing requirements elicitation techniques, conceptual modeling, and database and interface design methods are inadequate when developing a UGC-based IS. A potential solution to this dilemma might come from research on innovative approaches to IS development. One approach is to reduce the extent and depth of specifications by focusing on basic conceptual structures—work that has been on-going in the context of agile development (Ambler 2003), but can also be motivated by PD challenges in UGC. Another promising approach is to allow users to dynamically change IS structures and components during use—exactly what WeatherRecorder’s investigators believe to have been a successful strategy in Phase 1. This resonates with a pre-UGC endorsement of flexible design by Bodker (1996, p. 11):

“[W]here much design is a matter of local adaptation of standard technology, a ... fundamental question is: how may we ‘globally’ support local [participatory design]...? First of all, flexible, tailorable, standard technology is a necessity.”

Similar suggestions have been made for designing social technologies; e.g.; Facebook; (Hagen and Robertson 2010). Adaptive, tailorable, personalized, and flexible technology is a growing research topic and a budding practice (Anand and Mobasher 2005; Germonprez et al. 2007). One could envisage a solution that takes advantage of the booming practice of data mining and artificial intelligence (Abbasi et al. 2016; Chen et al. 2012), including machine learning and natural language processing (Larsen and Bong 2016; Sabou et al. 2012), where, for example, machines interact with users and dynamically adapt to variable user views and styles or perform tasks that are otherwise problematic or difficult for users. Presumably, such approaches would

address some of the challenges involved in developing systems that face extreme heterogeneity of user views. An unanswered question, however, is:

*What do these intensive computational technologies mean for PD? Should these systems themselves be also shaped by the users and, thus a subject of PD?*

Research has been conducted on design for individual users; e.g.; managers, power users; and people with physical or cognitive impairments (Holone and Herstad 2013; McGrenere et al. 2006). Most of this work does not explicitly consider our kind of UGC settings; thus it is unclear how much of it is immediately applicable to UGC and how much requires adaptation. Phase 1 of the WeatherRecorder project involved a small group of like-minded experts, but despite its success, this approach was not chosen for the Phase 2. It is not known how to develop a highly multiuser system that is fluid (changeable) throughout its lifecycle.

One strategy might be to make some components flexible and others rigid. For example, rather than making the entire IS flexible, Phase 2 of NatureWatch's adopted a novel instance-based database structure (while keeping many other features fixed and rigid).

*An open challenge is determining features that should be flexible (or tailorable), and those that remain fixed, with corresponding issues of user involvement in generating these features.*

## 4.6 What PD approaches are effective?

Finally, as UGC is quite different from traditional IS, it opens an exciting opportunity to develop, deploy, observe and evaluate novel PD methods and techniques. NatureWatch used a combination of existing and some emerging PD techniques, such as continuous user involvement and development inside a biology laboratory. WeatherRecorder experimented with decentralized development and now faces an exciting challenge of scaling its successful model to a vastly larger user base. In one citizen science project, PD involved living with the aboriginal tribes and co-developing novel forms of symbolic communication (later translated into user interface options) (Stevens et al. 2014; Vitos et al. 2013). Studies (including both cases in this paper) so far offer only preliminary evidence (often anecdotal) of the effectiveness of PD solutions in emergent settings. There have been increased calls for novel approaches to PD, particularly due to the growth of the Internet and social media (Hagen and Robertson 2010; Kyng 2010; Shapiro 2010). Beyond suggesting new techniques, we believe:

*What is also needed is a systematic and rigorous evaluation of different PD approaches in UGC settings, including with tighter controls to permit stronger inferences about the effectiveness of given PD methods and techniques.*

## 5 Conclusion

The explosive growth of UGC motivates research on addressing the challenges of developing UGC projects from a participatory design perspective. This work answers increasing calls to

consider PD when users are “non wage-earners” in “non-workplace settings” (Kyng 2010, p. 63). Rather than present solutions, we contribute by identifying and analyzing challenges of conducting PD in these settings, and suggesting fruitful unresolved issues to be pursued in future studies. Recent arguments in the philosophy of science (Hoyningen-Huene 2008, 2013) call for more work on understanding and describing phenomena (rather than, more traditionally, theory-building and testing). Concomitantly, we contribute by methodically analyzing the nature of UGC and positioning it in the broader landscape of PD research so that gaps in understanding can be revealed, and conceptual bridges can be built between UGC and existing PD knowledge. With this work, we hope to inspire future studies that build on the long tradition of PD by extending its concerns to an increasingly important class of information systems, but also considering any lessons from UGC for distributed and traditional PD.

Finally, for the purposes of this paper, we restricted our attention to organization-led UGC and based our analysis on cases where the system can be considered in the public interest; e.g.; citizen science; However, UGC is becoming incredibly diverse, including mining existing data sources; e.g.; Twitter; cases where organizational role in driving development is minimal; e.g.; OpenStreetMap; (Haklay and Weber 2008), UGC-style development within corporate settings; e.g.; employees wikis; (Jackson and Klobas 2013), product development contests, online reviews, and other types (for recent taxonomies of UGC, see Brabham 2013; Prpić et al. 2015). These settings are likely to be somewhat different from those explored in this paper and bring their own challenges and questions. We hope our work on organization-focused UGC can motivate similar studies on other exciting areas requiring investigations.

## Notes

1. Crowdsourcing is somewhat different from organization-directed UGC, as beside information it also encompasses contests, fundraising, problem solving, digital and physical product development (Brabham 2013; Doan et al. 2011).

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