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Patients Participate! Literature Review



Usability and human factors in citizen science projects, and trust and credibility on the Web.

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Patients Participate! Literature Review: Usability and human factors in citizen science projects, and trust and credibility on the Web.

Monica Duke and Emma Tonkin, UKOLN.

Introduction

This review was written for the Patients Participate! project. The Patients Participate! Project is a 7-month feasibility study to investigate bridging the gap between information access and understanding. Specifically, the project wanted to explore whether lay summaries can assist in the wider understanding of health-related information and whether the crowd-sourced lay summary is a feasible mass-production model. This review examines human factors as reported in the literature for projects using citizen and human factors applied to user trust and perception of the credibility of web sites and content, in order to identify factors that could contribute to the feasibility study. Other outputs from the project include a workshop, case studies and guidance documents. The deliverables can be accessed from <http://blogs.ukoln.ac.uk/patientsparticipate/>

Methodology

The main body of this literature review (Human Factors in Citizen Science Projects) was conducted according to the following methodology: a set of papers and articles discussing either citizen science and/or public participation in, and understanding of, medical research information were collected in the 'PatientsParticipate2011!' group on Mendeley. The papers were submitted to the Mendeley Group by project staff familiar with the project scope. The paper titles were then analysed by Monica Duke and a set of 10 papers selected based on two criteria: (1) Those that were more likely to be about Citizen Science projects (e.g. contained the phrase citizen science in the title or mentioned a known citizen science project) and (2) those most likely to contain comment relevant to usability and human factors (e.g. mentioned motivation in the title).

Limitations: Due to time constraints, this review did not attempt to be comprehensive: (1) only a subset of articles included in the Mendeley group were reviewed (e.g. those that were judged to be out of scope from the title because they did not specifically address citizen science projects). (2) The collection of papers collected in the Mendeley may not be wholly representative of the body of literature on Citizen Science and represent the literature that the project team became aware of during the brief lifetime of the project.

In this review, we also explore relevant literature on web site user retention and loyalty, and on user trust and perception of the credibility of web sites and content.

What is a citizen science project?

'Citizen science' is a modern term for an old concept. The idea that special qualifications are required to participate in the process of scientific investigation is more of a recent anomaly than a general rule. Historically speaking, science has often been perceived as a reasonable pastime for the wealthy and idle, especially in certain fields; Aristotle, for example, concluded that the sciences are a leisure activity, to be developed through idle investigation rather than immediate necessity.

Other examples of leisure pastimes that developed into science are offered by the Polish mayor Johannes Hevelius (1611-1687) who founded the field of lunar topology; the German poet Johann Wolfgang von Goethe (1749-1832), who found time to contribute to the fields of botany, colour theory and anatomy alongside his employment at the Weimar Court and achievements in German literature; and Gerald Durrell (1925-1995), who began his lifelong career as a naturalist in Corfu, under the mentorship of a scientist and polymath who happened to live nearby.

The availability of free time, sufficient funding, sufficient education, opportunity and curiosity have been catalysts for involvement in science throughout history. That the segment of the general public who enjoy these resources from science and the scientific process appear to feel alienated from the practice of science is therefore a concerning phenomenon; Holton (1996) describes an 'ever-widening gap' which separates knowledge and the scientific world-view from the understanding of the general public. It is perhaps emblematic of our age that we see the idea of a 'citizen scientist' as any more noteworthy or improbable than an amateur painter or keen gardener, yet we find outreach between scientists and the general public in either direction a sufficiently noteworthy occurrence that a specialised vocabulary has been developed for the purpose.

According to Clark and Illman (2001), a civic scientist is a scientist who communicates with general audiences, who is engaged in public outreach – who has as an objective to 'inform citizens of how science functions or contributes to our society' (Snow, 1996). A citizen scientist is a member of the lay public who 'engages in communication with scientists or participates in scientific activities as citizen scientists or citizen volunteers'. This definition is extremely broad, and consequently Clark and Illman (2001) propose a more detailed typology of participant profiles:

- *Citizen scientists*, who 'attempt to evaluate scientific arguments used in the context of social issues' (for example, climate change).
- *Citizen volunteers*, taking an active role in the collection or analysis of scientific data. This is referred to by Clark and Illman (2001) as the 'Audubon model', after a 110-year-old project led by the Audubon Society, the Annual Christmas Bird Count. Many other examples of this model exist, such as the National Weather Service's 120-year-old project working with volunteers to collect data including rainfall and temperature and the National Marine Fisheries Service's half-century-long project tracking fish population with the help of volunteers.
- *Citizen-activists*, who independently work towards scientific goals: for example, monitoring environmental damage resulting from commercial or governmental activities.

Of these, the citizen volunteer is the closest match to the use of the term 'citizen scientist' as it is applied by a number of recent projects. For example, the astronomy project Galaxy Zoo makes use of volunteers to solve an image recognition problem

that, in the majority of cases, requires very little detailed knowledge, but which humans can solve more effectively than computers – a shape-recognition ‘human intelligence task’.

This review covers a number of examples of ‘traditional’ citizen science projects and outcomes (such as distributed data collection roles), but is primarily focused on web-based citizen science projects, such as crowd-sourced data analysis or aggregation of user data and/or reported experiences.

Human factors in citizen science projects

General factors to be considered when carrying out a citizen science project

Whilst focussing on the use of mobile devices with sensors to collect data in citizen science projects, Paulos (2009) suggests an operational framework for citizen science and outlines a series of significant research themes, clustered around the various activities that citizen scientists engage in. He segments these questions into four general areas: data collection; expression (that is, scientific notation, formats, encoding, and presentation to the end-user); data sharing, and using the data to enable **change**. Some points made by Paulos (2009, pp. 2-3) are summarised here:

1. **Data collection.** It is necessary to characterise the type of data collected, its source, and the mechanisms - either technical (e.g. sensor-based) or social (e.g. user-contributed) - applied for this purpose. In doing so, can we be able to understand better the motivations of participants and identify how others may be motivated to participate? In the case of sensor-based data collection, Paulos asks whether the choice of sensor differs depending on user profile (i.e., individual, policy-maker, scientist?) and how practical barriers (for example, integration of sensors into mobile platforms) can be solved?
2. **Expression.** The focus of Paulos’s work on sensor-based data collection leads to specific difficulties, such as limitations in accuracy, calibration problems, and so forth. The data may be expressed in a number of ways: as a single data set, or as part of an aggregated collection from a large number of users, if appropriate networking is available. Ubiquitous computing theory also suggests that data expressed to a user need not be read directly from a screen in a traditional dialogue box, but can be expressed otherwise; Paulos asks what effect this may have – can these approaches ‘inspire more persuasion, curiosity [...], sensor literacy’ and so forth, affecting the motivations of the crowd? Which interaction paradigms are appropriate, and in which contexts?
3. **Sharing data.** Once data is collected, much of its value is often as part of an aggregate set. For Paulos, this raises questions such as the choice of data sharing protocols, formats and so forth, as well as the need to verify the validity of information retrieved (including, perhaps, both the possibility of systematic error and that of intentionally invalid information - ‘poisoning’ the dataset). For

Paulos's application, ensuring that privacy concerns are identified and handled is a significant concern: for example, a dataset containing a GPS trace and a device's unique identifier may provide significant information about the owner's everyday life. Data must also be stored and made available to those likely to make use of it: 'archived, preserved, and authenticated'. Possible audiences for the data must also be explored, so that appropriate mechanisms for sharing data may be identified and implemented. There is a further problem, too: that of fair use and data ownership.

4. **Enabling and identifying change.** This is a relatively broad category; in short, Paulos asks what impact will technology have? How can it be used to foster change and (it is hoped) benefit society? In general, how can people be encouraged to take part, and how can the features and limitations of the resulting data be made clear?

Cooper et al (2007) identify a set of key features of undertaking a citizen science project:

- Procedure for establishing goals
- Recruitment and marketing: identifying and reaching target communities
- Training participants
- Retention of participants
- Data collection and organization
- Feeding back results
- Management recommendations

Key features of undertaking a citizen science project

(Source: Cooper et al, 2007)

These features are complementary to the framework given by Paulos, e.g. recruitment, marketing, training and retention of participants address different aspects of data collection and the question of user motivation. Some other overarching questions are also addressed, such as goal-setting for the citizen science project. Cooper et al. suggest that project goals will in the main be set by the organisation behind the initiative, although inclusion of the participants in goal-setting could also be considered. The idea that participants are provided with feedback on results is a cornerstone of this approach. Participants can also be consulted to collaborate in the planning of new management strategies or to monitor the effects of a chosen approach on an ongoing basis.

Recruiting and building on-line communities

Raddick et al (2009b) describe how the Galaxy Zoo project was launched with the help of the media, starting with a BBC Radio news item (<http://news.bbc.co.uk/1/hi/sci/tech/6289474.stm>) and the immediate effects this had on recruitment. Following the radio feature, the news then spread via international print and online media, increasing participation dramatically. 1.5 million

classifications were achieved within one day of launching. The response also precipitated large numbers of emails, so a forum was launched to enable volunteers to help answer each others' questions. The organisers found that volunteers are prepared not only to carry out the specific task of classifying galaxies, but are also ready to get involved in helping each other through forums and carrying out collaborative research.

Communication amongst participants is also a key principle behind Patients Like Me (<http://www.patientslikeme.com>). The site has chosen to prioritise enabling peer-interaction over the provision of authoritative medical advice through the site, thus standing aside to encourage patient-patient exchanges of information derived from individuals' own personal experience, published through the medium of personal pages and forums (Brownstein 2009). Through the site, patients can also participate in experiments, and are involved in collecting certain types of data, such as adverse effects (side-effects).

The organisation of the web site itself is informed by this overriding principle of peer interaction; all 40,000 patients are organised around disease communities. Patients can anonymously share their personal treatment, symptom, progression and outcome data, and participation is free. The site is intended to be free of advertising material other than the exceptions mentioned here. The business model is based around selling anonymised aggregated data, alongside collaboration with the industry and academic researchers to facilitate market research and promote clinical trials.

The site has been built around the assumption that patients are looking to answer a primary question, 'Given my current situation, what is the best outcome I can expect to achieve and how do I get there?' (Brownstein, 2009) The site's features and toolset are designed in the hope of enabling the user to answer different parts of that question. For example, a patient can match their 'current situation' to the available information according to various categories of data: genetics, disease characteristics, and so forth. In other words, the site aims to offer useful and relevant information pathways to the user groups its creators hope to attract.

Participant motivation

Raddick et al (2009b) reviewed the literature on motivation of citizen scientists, noting that 'The majority of research has only been published in the current decade' and most studies concentrated on benefits for citizens and scientists (ignoring the issue of participant motivation), with no studies involving only completely on-line projects. They report that in the Florida Fish and Wildlife Conservation Commission, the most popular reason that participants gave for their involvement in the project was a wish to "help and protect sea turtles", while in a survey of volunteers at the Ohio Chapter of the Nature Conservancy, 63% ticked the box that said they wanted to "do something for nature". However, the authors noted that internet-based citizen science projects often differ from the examples given above,

as this type of project often invites citizens to analyse data (as well as, or instead of, creating it) and participants are often encouraged to communicate with others online.

The authors described a method they used to explore the motivations of the volunteers taking part in Galaxy Zoo. Their approach consisted of two phases. In the first phase they identified motivations and defined motivation categories in a pilot group. In the second and larger study, the researchers sent a survey to a large number of volunteers, using the category motivations from the first phase as source material in the design of the survey.

In the first phase, two methods of collection were used, responses given in an open forum and interviews with individual subjects. The forum request, asking volunteers to describe why they were taking part, generated 826 responses. The interviews were held with a pool of 22 volunteers, representing a tiny fraction of a percent of the Galaxy Zoo volunteer population. Interviews were conducted by instant messaging or by phone. The interview transcripts were then examined to extract statements of motivation, which were then categorised. The authors describe in detail the method used to come up with 12 motivation categories, which were cross-checked against the forum responses to validate the categories and identify any gaps; by this method, they successfully compiled a set of motivation categories for Galaxy Zoo volunteers, which they deemed 'complete' (encompassing all likely responses). Consistent with other studies, they found that more than one motivation was commonly present. They assert that using a very small sample of interviews with individuals is a reliable method for identifying the motivations of large volunteer populations, although larger interview sets are recommended.

Nov et al (2011) provide a number of pointers to literature that explores the motivation of contributors, both to citizen science communities and to other information-sharing communities like Flickr, Delicious, Twitter, YouTube and Wikipedia. Motivation is described as being either extrinsic (e.g. improvement of skills and enhancement of status) or intrinsic, examples of which include fun, intellectual stimulation and a sense of obligation to contribute. The authors also point to other factors influencing individual levels of participation and contribution, which have previously been explored by other researchers, such as the following:

- the social network properties (that is, the way in which individuals are linked together; the amount of communication occurring between users; the types of exchange/communication that take place and the amount to which individuals reciprocate contact, and so forth – see Sohn et al, cited in Nov et al, 2011),
- group membership size - an under populated group may feel empty, but a very 'busy' group may feel intimidating, for example - and
- the quantity and quality of feedback received.
-

Additionally, the authors identify an apparent scarcity of research on the factors

driving online citizen science participation in general.

Raddick et al (2009a) focus on the question of sustained motivation and engagement, proposing that motivation may be sustained through:

- Studying “**who participates** in citizen science, and **what motivates them** to participate at various levels of engagement”
- Ensuring that the proposed activities and resources are appropriately chosen. Raddick et al propose that pilot activities should be developed using the most appropriate tasks and datasets, with an eye to incorporating citizen science projects into school/curricular activities and into museum-based activities.
- “Recognizing volunteers as research collaborators,” identifying their collective contributions, and, where possible, identifying volunteers by name on an individual level. This helps with motivation, providing an incentive to increase one's level of involvement.
- It is proposed that organisers assess “what volunteers learn about scientific content and process”, and record both participants' pre-involvement viewpoints and changes in participant attitudes towards science as a result of involvement, in order that resources may be developed to accelerate or enrich the ongoing learning process.
- “Encouraging development of citizen science projects such that old projects can bridge into new projects, with the same volunteer community and standard interfaces” (creating lower barrier to entry by using the same interfaces throughout a series of interlinked projects; they recommend that designers of existing and new Citizen Science projects work closely together to establish and implement best practices in Citizen Science project design.)

Participant motivation is treated by Raddick et al as a primary factor in retaining and making use of volunteer effort; the proposals above suggest that the volunteer benefits from being seen as a valued team member, and that the citizen science platform benefits from treating the volunteer accordingly. Whilst the volunteer benefits from training (making pupils and students a user group of particular interest), the consequence of this is that they may become increasingly valuable to the team as they develop their skills. It may therefore be too simplistic to see participants in citizen science efforts as simply interchangeable members of the public; under some interpretations of the concept, they become lay experts.

Learning from ‘sticky’ websites: encouraging return visits

There is a significant body of research on the subject of user loyalty and how to encourage return visits to websites, and it is impractical to review it exhaustively here. To briefly review, however, we may begin with Everitt et al (2009), who report that the average user has passworded accounts on 25 separate websites, a number sufficiently small to suggest that there is some resistance to signing up for accounts.

Reichheld and Schefter (2000) emphasise this factor, suggesting that loyalty is ‘an economic necessity; acquiring customers on the Internet is enormously expensive’. Whilst there is broad agreement of the benefits of retaining viewers, there exist a broad variety of opinions on precisely which factors can be relied upon to keep the site high in user browsing preferences – or drive them to delete the bookmark.

Kuan et al (2005) identify the quality of service as a factor – whether the site can be relied upon to achieve the desired outcome. Gong & Wu (2011) concur, describing loyalty as contingent upon the level of service provision. Users whose requirements are met by a site are more likely to return to that site. König (2009) identifies the frequency of updates of a site as a factor in reader loyalty – readers are more likely to return if they are likely to find something new of interest to themselves. Content provided should be substantial (Gong & Wu, 2011), and relevant activities should be offered to incoming viewers (e.g., in the case of a blog, reading and commenting).

Retention in areas more closely related to citizen science activities, such as e-learning, may require a slightly different approach. In brief, Packham et al (2004) enumerate a number of factors of relevance to withdrawal from e-learning courses, that may also be of relevance to volunteer retention in citizen science (assuming that the volunteer is partly ‘paid’ for his/her labours in the currency of knowledge): impact of limited available time, versus the time required to master relevant pedagogical aims; IT and technical problems; lack of technical and procedural support; poor usability; failing to meet user expectations; a lack of clear information and failing to manage initial expectations.

Immersion into a novel area of expertise is a process dependent on mastering relevant background information, skills and rules. To some extent this is manageable through appropriately timed presentation and a reductive approach to task analysis (i.e. treating the would-be citizen scientist as an unskilled volunteer), but this approach, if taken to its extreme, provides the volunteer with no pathway to progression, and may therefore result in limiting the duration of the volunteer’s involvement.

Cooper et al (2007) advise that ‘retaining participants [in a citizen science project] requires consistent support, including rapid response to questions and suggestions as well as online resources for communication among participants.’

Beneficiaries of citizen science projects

Raddick et al (2009a) identifies four categories of beneficiaries of citizen science:

- The science community is able to complete projects which would not have been completed without volunteer effort, perhaps as a result of the large size of the datasets involved.
- Volunteers benefit through enjoyment, finding a social community and through being able 'to participate in real science'.

- The education community benefits through opportunities to promote science literacy. Volunteers gain opportunities for contact with scientists as well as experiencing the process of science.
- Benefits to society as a whole include the potential for building closer connections between scientists and the public.

Note that these are not all applicable to every project that might be described as an application of 'citizen science'; many projects specialise the task at hand to the extent that the participant is involved in 'the science' only very peripherally, for example, and therefore may not gain direct experience of 'the process of science'. Similarly, a project like Galaxy Zoo has many tens of thousands of users - Phase 1 of Galaxy Zoo involved 82,931 users (Lintott et al, 2008) – and therefore the vast majority of users are unlikely to have the opportunity to communicate individually with relevant scientists.

Citizen science projects can produce valuable and important data, and it may indeed be incumbent upon (or at least strongly advisable to) those who engage citizen scientists to fulfil their half of the employment equation by providing pathways for progression into a deeper involvement with the 'real science' that Raddick et al mention above. It is by no means clear that such opportunities routinely result from involvement in citizen science projects.

Effects on participants

Cooper et al (2007) suggest that 'Most citizen science projects have an underlying, testable assumption that engagement of the public in the process of research has scientific, educational, attitudinal, and behavioural outcomes.' and report that one consequence of citizen science has been to increase the ability of participants to frame questions scientifically. They consider the social outcomes of citizen science projects to be just as important as the scientific outcomes: for example, changing the attitudes of participants is a valuable outcome. Their studies involving residential ecosystems showed that, because the project brought the public to directly manipulate their environment, involvement affected social and behavioural factors: in the examples given by Cooper et al, participants' attitudes are described as having changed markedly as a result of involvement.

Brossard et. al (2005) analysed the impact of The Birdhouse Network of the Cornell Laboratory of Ornithology on participants' attitude, knowledge and understanding. They noted that the effect of citizen science projects on participants' knowledge and attitudes toward science is yet to be documented, and found that there is very little standardized comparable data. Where evaluation is carried out, they identified a lack of hypotheses that would help implement sound evaluation plans. The study describes its methodology in detail, implementing rigorous and standardized methodologies for measuring knowledge and attitudes and for building and testing hypotheses. The study concluded that although the project had increased the participants' knowledge of bird biology (the specific topic at hand), no statistically

significant change in participants' understanding of more general subjects such as the scientific process, attitudes toward science and attitudes toward the environment could be detected.

Moy et al (2010) report on a graduate-class project in which participants edited chemistry-related entries in Wikipedia. This project represents an example of the use of a social content creation platform to complete a task, whilst at the same time illustrating more general principles; the exercise was intended to help the participants (in this case, students) to learn how to communicate advanced science concepts to a general audience. The students worked in groups and selected a chemistry topic that was not already well covered in the online encyclopaedia. After receiving handouts on relevant technical skills (how to edit Wikipedia and work with images), the students wrote the proposed text, which was reviewed prior to the addition of students' entries to the site. The entries were then assessed based on specific criteria, including the provision of an introductory paragraph for the general public, the addition of original images and the creation of links to other articles. The revised Wikipedia entries were also assessed by an independent reviewer. The project highlighted editorial aspects of Wikipedia that need to be considered when undertaking such a project (e.g. holding group accounts), and the authors have shared a handbook ('Editing Wikipedia as a Class Project') to help facilitate similar projects in other settings.

The project was well received by the students and was perceived as having provided a beneficial opportunity for them to take responsibility for editing a popular resource, as well as resulting in an improvement in the Wikipedia pages to which they contributed. When the students evaluated the course, putting the Wikipedia exercise in context (using a panel approach evaluation), they assessed it as the most useful of the available resources (compared to others such as class lectures and textbooks) for the goal of learning to work collaboratively. Selecting from a list of goals which the class could have achieved, the students reported that the exercise had made a significant contribution to the goals of 'communicating science to a diverse and general audience' and 'identifying appropriate references and other resources for building an argument.'

Ensuring quality of data

Kim et al (2011) discuss the problem of ensuring that useful data is captured, and suggest that both the data capture interfaces and interfaces designed to make data available for end-users should benefit from HCI methods and principles during the design phase. They point out that the success of a citizen science project cannot be measured only by the levels of engagement and the amount of data contributed, but also by the impact and usefulness of the data collected. The design must be driven in part by the data consumers, and through an understanding of the needs of the groups who will use the data, not simply by focussing on the volunteers who will be submitting data. The users of the contributed data must be considered equally as a stakeholder group, unless the users are both producers and consumers.

They identify and address a need for data standardisation in the way data is collected and stored. This tallies with the recommendation provided by Raddick et al (2009a) that citizen science projects should develop an understanding of how to 'calibrate' user contributions into science data. They propose that a trade-off is required between the need for data that adheres to a standard and protocol that makes it useful, and the need to make it easy for citizens to collect the data in a reliable and predictable way.

With respect to potential errors that can be introduced into the collected data due to mistakes, bias and so forth, Kim et al (2011) suggest that mechanisms are needed to allow consumers to verify the data (in their study, for example, photographs of trash in rivers provide supporting evidence for participants' recording of the level of contamination). They observe that contributors like to check data entered by their peers in order to compare results, which leads them to point out a potential opportunity to seed the data with ideal samples, thus using the natural competitiveness of contributors to drive up the standard of contributions when there is good data to refer to and to be used as a golden standard against which participants measure their contributions.

Paulos (2009) also draws attention to potential sources of error, including: the need to be aware of bias that can be invested by the name of an artefact (e.g. calling sensors 'pollution' sensors); the possibility of malicious use, when contributions turn out to have a negative use; the consequences of increased awareness that results from participation, alteration of the quality of data as a result of increased exposure to and experience with the data or the collection process; use of any available mechanisms to lodge complaints, direct blame and so forth.

Alabri et al (2011) identify 3 weaknesses in Citizen Science projects which can lead to poor quality contributions:

- limited training, knowledge and relative anonymity of contributors
- the absence of formal "scientific methods" and the use of non-standardized and poorly designed methods of data collection
- lack of commitment from volunteers can lead to gaps

They suggest two ways to validate data:

1. comparison with valid data (requires good samples to compare against)
2. using social networks to provide a measure of trust in the data; the authors suggest that current trust models and metrics developed for Web 2.0 have not yet been tried in citizen science.

They provide a list of data quality measures that can be applicable to citizen science projects (with definitions in Table 1 in the paper): Accessibility, Appropriate amount of Information, Believability, Completeness, Concise Representation,

Consistent Representation, Ease of Manipulation, Free-of-Error, Interpretability, Objectivity, Relevancy, Reputation, Security, Timeliness, Understandability and Value-Added.

They tested the following set of attributes for measuring trust using a combination of characteristics of the contributors:

- The contributor's role and qualifications (they suggest classifications such as primary student, secondary student, PhD student, volunteer, council worker, scientist.)
- The quality and quantity of past data contributed by that individual.
- The extent of training programs completed
- Frequency and period of contributing
- The contributor's ranking by other members (direct, inferred or calculated using social trust algorithms).

They also tried to identify optimal mechanisms for displaying and communicating trust level, quality of data and reliability of contributors, to other members of the community. During evaluation the users and administrators suggested that trust metrics should be hidden for individual users, but could be made explicit for specific datasets. Trust metrics could be used instead to target online training modules to individuals (who have been ranked poorly by the system) or reward and encourage those with a good metric (to help with retention).

The authors implemented a system that demonstrates that, in this case study, it was possible to significantly improve the quality of community-generated observational data through a set of validation and verification tools. They also proposed a measure of the reliability or trustworthiness of citizen science data that may be calculated using a weighted aggregation of both direct and inferred attributes. The detailed methods required for collection and storage of scientific data may need to be adapted for other types of contributed information, although some generic principles may apply more broadly. Finally, they also noted that it was beneficial to provide both data of immediate use to potential consumers and data intended for longer-term use, since this broadens the potential set of users while ensuring that immediate interest is attracted and retained.

Instilling doubt

Paulos (2009) suggests that doubt is a useful quality that should be encouraged across the board in citizen science: both when volunteers are evaluating data they have collected, and when they are dealing with figures that may appear 'authoritative'. He identifies a design requirement to harness participants' own abilities to apply data checking measures, whilst they are collecting data. He concludes that 'What is clear is that we must design citizen science systems to instil elements of doubt when users engage with these datasets.' He reports that observations have shown that when given devices for data collection, users will

design their own experiments to confirm that the device is working properly. Users thus exhibit 'doubt' and take measures to have the doubt confirmed or contradicted.

Credibility, trust and barriers to involvement

The involvement of volunteers in citizen science will be influenced by the perceived trustworthiness and credibility of the user interfaces being used for data collection or analysis. This section will review some of the HCI literature relating to the credibility and trustworthiness of websites and online content. Perceptions of credibility and trust are popular subjects for HCI research, primarily because of the financial consequences that a poor first impression would have in the commercial sector (e.g. online storefronts). However, some of the same factors are also relevant to involvement in crowdsourcing and in citizen science, but for slightly different reasons.

Low scores in trustworthiness and credibility are likely to become barriers to involvement for several reasons. This may impact on the success of data collection; for example, a site that scores poorly on credibility or trust is unlikely to succeed in gathering sensitive data such as confidential medical information.

If perceived credibility and trust are lacking, users (researcher, citizen scientist/contributor and viewer alike) may also feel less confident about the data presented by the site, and as a consequence, may be wary of any conclusions reached on the basis of that data.

Defining trust and credibility

HCI research may focus on 'trust' – a concept more frequently referenced than defined. According to Corritore et al (2007), positive perceived factors influencing trust include credibility and ease of use. Negatives include perceived risk. Corritore et al explored the possibility that an inverse relationship exists between credibility and perceived risk, and between ease of use and perceived risk; they found evidence for the former relationship only (i.e. low credibility is associated with high risk).

In a 2003 study of over 2,000 participants, administered via an online study site (i.e. essentially questionnaire-based), Fogg et al (2003) invited users to evaluate the credibility of web sites. The quality of credibility is described in their study as being, 'created through simultaneous evaluation of multiple sub-factors including expertise, honesty, reputation, and predictability'. From this study, they found that the most frequently cited indicator of a site's credibility was its look and design (cited by over 46% of users). The second and third most cited issues were information design/structure and information focus (at around 25% incidence); the fourth was the user's evaluation of the company's motive (at around 15%).

Fogg et al (2003) also identified further factors of relevance to perception of trustworthiness, including the provision of comprehensive information, 'projecting honesty and shared values', and 'conveying expertise'. They also identified less frequently studied factors, such as predictability, i.e. the consistency of behaviour on

the part of the site/controlling agency.

A study by Roy et al (2001) studied the relationship between the quality (or usability) of interface design and the level of trust of potential customers, and found a strong relationship between them. They explored this using an index of usability 'aspects' adapted from Nielsen by Lin et al (1997). Particularly significant aspects of user interface design to user trust included navigation, perception, and support – that is, ease of navigation, the fact that the design takes into account human perceptual limitations, and the level of guidance provided to the user (limiting required 'mental workload').

Egger (2001) noted that users are typically predisposed to trust/distrust certain sites based on pre-existing knowledge about various aspects of the site (i.e. controlling agency, brand, etc). Therefore initial access to a website results not in an initial judgement but in a re-assessment of the 'initial trust value', the user's initial opinion of the site's trustworthiness. They also identify transactional/time-based factors such as relationship management, success/failure of interactions, transactional risk, and so forth.

Sources agree on a number of basics: for example, perceived trustworthiness and credibility are generally understood to be functions of user judgement of various factors, although the choice of factors to be evaluated varies. Egger points to user psychology, noting Deutsch's (1960) finding that individuals differ greatly in their readiness to trust. He identifies cultural factors that correlate with altered propensity to trust, such as nationality, trust in/familiarity with information technology, and 'general attitude' towards the type of activity in question, i.e. e-commerce, data compilation.

Trust evaluation in use

Egger (2001) recommends beginning by knowing your customers; identifying and targeting customer segment(s) of relevance, establishing profiles for each group, and determining their levels of proficiency with relevant areas (i.e. IT, e-commerce, etc). He recommends investigation of your organisation's brand equity, and user attitudes towards the industry; and, of course, he recommends the manipulation of these variables through targeted marketing, including traditional channels of advertising and viral marketing. Branding and generally good usability alter the user's judgement of the site, and are therefore of relevance. However, the model he proposes clearly presents customer/user profile and perceptions as key to evaluating trust judgements.

Perceptions of trustworthiness are often related to the branding of the site and its parent institution(s). Peters et al (1996) found that trust and credibility are key variables in reduced public confidence in governmental institutions' judgement of environmental risk, and in a corresponding increase in citizen groups working in the same area. A poorly presented site can damage public perception of the institution

behind it, and interested members of the public instead seek alternative sources of information. That said, many factors may influence the public perception of an institution, including macropolitical factors, stereotypes and predisposition; Peters et al list perception of knowledge and expertise, perception of openness and honesty, and perceptions of concern and care.

A second rule might therefore be proposed to accompany Egger's maxim: Know your customers, and know your brand.

Credibility of information objects on the Web

Research typically focuses on web site credibility as a whole, rather than the effects of web site credibility on a given text or object presented via the site. As a consequence, much of the research available is difficult to apply directly to typical citizen science problems, which often require users to engage critically with information objects presented to them for analysis or review.

Exceptions to this include literature reviewing student performance in establishing the credibility of content found on the web, such as the discussion by Iding et al (2002) of strategies used by computer science students in evaluating the quality of information. The study focuses on choice of site rather than information object, but engages with the problem of evaluating specific content within the site. One reason given by study subjects for preferring one resource to another as a literature source is, 'when it contradicts info you already know'; another is 'presence of references'.

Iding, Nordbotten and Singh (2006) expand on this finding, exploring credibility ('information accuracy and veracity') determinations carried out by students. They note that, according to Klemm et al (2001), education level correlates negatively with high judgement of credibility (i.e. those with a higher level of education rate the credibility of a given resource less highly). Their findings indicate that the population of students studied (Norwegian university students) put relatively little importance on presentation and design, focusing instead on objectivity and accuracy. This suggests that under certain circumstances (during certain tasks), user judgement in critically evaluating content depends on different factors to the presentational factors mentioned previously, but on other heuristics. On the other hand, Iding et al (2002) note that university-level students 'have limited understandings of the concept of "vested interests"'; the type of critical evaluation desired for this purpose takes time and training to develop.

From this we conclude that user judgement is not only constrained by cultural background and familiarity with technology, but also by the class of evaluation that is involved, and pre-existing familiarity with the activity. Presentation acts as a sign of professionalism in a commercial environment, but has less relevance as a marker in an academic environment. This suggests that judgement of the credibility of an object/document/text is related to a large number of factors, in varying levels of importance depending on the context of use/search: the site on which it is found,

the author/originator(s), the presentation of the document, perception of accuracy (i.e. fit with existing knowledge), and so forth.

Practical consequences of trust and credibility in citizen science

The relevance of trust and credibility are related to the chosen task, interface, audience, subject and protagonists. Relating the general findings given here to a specific task is non-trivial and, as is typically the case in human-computer interaction, greatly facilitated by an experimental and user-focused exploratory phase.

Taking the example of the Patients Participate goal of authoring and reviewing lay summaries, here are a few examples of processes that may be influenced by user perceptions such as those given above:

- Authoring
 - Participants without formal qualifications may be intimidated by the need to put their real name to contributions
 - Participants may be uncomfortable releasing personal data, even indirectly, to seemingly untrustworthy website. Such a reaction may be mitigated: the organisation should work with the participant to ensure that their concerns are responsibly identified and handled, for example, by publication of an adequate data management strategy, a clear privacy statement and an adequate data anonymization process. However, the work of researchers such as Ohm (2010) shows that the release of sensitive personal data, even in 'anonymized' form, may be riskier for participants than might generally be expected; despite the deletion of personal identifiers, most people can be re-identified from a supposedly anonymous dataset, using as little information as birth date, sex and approximate location.
- Editing
 - Decades of research into peer-review (refereeing) in the research environment have given rise to plentiful criticisms; it is a system 'riddled with sexism' (Wennerås & Wold, 1997) and prejudiced through confirmatory and other forms of bias (Mahoney, 1977; Fisher et al 1994). This gives us a good basis on which to hypothesise about the likely factors in participant peer review; we may expect identity (and linguistic cues regarding identity, gender, background and so forth) to play a role in reviewer bias, and for reviewers to reflect social factors such as the author's profile in the community in their review.
- Presentation
 - The presentation of a given document object may have a significant impact on the reader's reception of it – their readiness to critique the work, to identify spelling mistakes, structural errors, or factual errors, for example. The evidence provided suggests that these factors may be offset with training. A process of recruiting and retaining volunteers may

usefully include 'training games' or practice for this purpose.

In each of these activities, there is reason to expect presentation and perception to play a significant role in shaping the result. Assertions such as the bullet-points given above may be tested through controlled experiments or through pilot studies (although a controlled experiment would facilitate the process by limiting the presence of confounding factors and providing for a controlled environment).

Conclusion

In this review, we have explored definitions of 'citizen science' and 'citizen scientist'. We have explored general factors of relevance to citizen science, and factors related to encouraging participation and retaining the interest of participants over a longer timescale. We have discussed potential and evidenced benefits of involvement in citizen science, both for individual participants and for organisations. We then explored issues in ensuring that the quality of data is adequate for its intended purpose, and strategies for encouraging participants to review and improve the quality of their own work. Finally, we explored the impact of credibility and trustworthiness on the Web in general, noting the relevance of broader socio-political factors such as attitudes to governmental institutions, public opinion relating to the subject in question, and so forth, and sketched out a possible application of participant judgement of credibility/trust to a sample problem: the authorship and review of lay summaries on the Web.

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