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Motivation and learning impact of Dutch flu-trackers

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Abstract

Many citizen science projects deal with high attrition rates. The Dutch Great Influenza Survey is an exception to this rule. In the current study, we conducted an online questionnaire (N=1610) to investigate the motivation and learning impact of this loyal, active participant base. Results show that the desire to contribute to a larger (scientific) goal is the most important motivator for all types of participants and that availability of scientific information and data are important for learning. We suggest similar projects seek (social) media attention regularly, linking project findings to current events and including the importance of participants' contribution.

Keywords

Citizen science; Public engagement with science and technology; Health communication

Context

Introduction

Citizen science, the involvement of citizens in the scientific process, is a growing practice [Bonney et al., 2009a; Silvertown, 2009]. Especially with increased use of technologies like the internet and smartphones, it is easy for the public to get involved in collecting or analyzing scientific data. However, the majority of participants contribute sporadically, or even quit after a short period of participation [Nov, Arazy and Anderson, 2014; Sauermann and Franzoni, 2015; Theobald et al., 2015]. The bulk of the work for many projects is done by a small percentage of active participants. Interestingly, the Great Influenza Survey, a Dutch citizen science project in which participants report their (lack of) flu-like symptoms, is an exception to this trend. Dutch flu-reporters appear to be very loyal and contribute data on a weekly basis. In order to gain a better understanding of the reasons why people participate in citizen science and especially what motivates them to stay with a project, we studied the GIS project and looked at participants' motivation and self-reported learning impact.

Citizen Science

In most citizen science (CS) projects, citizens participate by contributing to data collection or analysis. To illustrate, many countries have yearly bird counts (e.g. Audubon Society's Christmas Bird Count), and other data collection projects invite the public to gather data on invasive species, water quality, or the weather [Bonney et al., 2009a]. Scientists benefit from the involvement of citizens in scientific research because this way they can gather large amounts of data from a wide geographical area.

Involving citizens in data analysis is beneficial in cases where the human eye is better in analyzing specific information than computers are. Examples of CS projects where the public is involved in data analysis are Galaxy Zoo and other Zooniverse projects [Reed et al., 2013], where citizens help scientists by analyzing telescope images of galaxies, by looking at images of animals in the Serengeti or by transcribing old museum records. The recent inaugural conference of the Citizen Science Association in February 2015 demonstrated that CS projects exist in many different subject areas including ecology, astronomy, psychology, biology, and health.

The growth of CS can partly be contributed to technological advances [Newman et al., 2012; Silvertown, 2009]. Online citizen science, also called virtual citizen science [Jennett et al., 2014], makes it easier for citizens and scientists to communicate with each other, to record observations, and to provide the data that needs to be analyzed. Smart phones are often used to record data [Newman et al., 2012], and have even been turned into scientific measurement devices [Land-Zandstra et al., 2015]. It has never been easier to become a citizen scientist when you can use a laptop at your kitchen table, or your smartphone on your way to work to collect or analyze CS data.

Scientific Literacy

Besides benefits for the scientific community, another goal of CS is to increase scientific literacy among participants [Bonney et al., 2009a; Riesch, Potter and Davies, 2013]. By their participation in CS, citizens can learn about scientific concepts, the scientific process and even change their attitudes and behaviors [Bonney et al., 2009a]. In this way, CS projects can be regarded as a form of science communication or informal science education. Especially contextual knowledge of scientific concepts, i.e. the scientific topics of the project, can increase through participation in CS projects, while attitudes towards science and behavior are more stable [Brossard, Lewenstein and Bonney, 2005; Crall et al., 2012; Cronje et al., 2011; Trumbull et al., 2000].

Engagement

Presumably, a more engaged citizen scientist is more likely to experience an increase in scientific literacy than a one-time contributor [Fredricks, Blumenfeld and Paris, 2004]. Loyal participants are also in the interest of scientists: when participants show up for training sessions, gather and report data regularly, and stay with the project for longer amounts of time this improves the amount and quality of the scientific output [Nov, Arazy and Anderson, 2011b; Riesch and Potter, 2014]. In the current study, we aimed to gain insight in these behavioral aspects of participant engagement, measured in terms of their frequency of contribution, the duration of participation, and their activity on other parts of the project such as reading the newsletter, interacting on the forum or social media and consulting the data.

However, CS projects, especially virtual citizen science projects, experience high attrition rates [Nov, Arazy and Anderson, 2014; Sauermann and Franzoni, 2015; Theobald et al., 2015]. Most people only contribute once and the majority of the contributions is often done by a small portion of contributors [Sauermann and Franzoni, 2015]. In a study of seven online CS projects, the top 10% of contributors in terms of the amount of hours they put into the project provided 79% of all contributions [Sauermann and Franzoni, 2015].

Still, Eveleigh et al. [2014] emphasize the importance of all levels of contributors. Even if most of the work is being done by the "super-volunteers", projects also benefit from the efforts of "dabblers", people who contribute intermittently on a non-regular basis. For example, a large turnover of participants may prevent people from going on auto-pilot and making mistakes. In addition, "dabblers" can be positive ambassadors for the project and may even turn into more engaged participants in the future.

Motivation

In light of high attrition rates it is important to gain understanding of what motivates people to participate in CS projects and especially what motivates them to stay with a project [Eveleigh et al., 2014; Nov, Arazy and Anderson, 2011a]. Previous studies have revealed different types of reasons for people to participate in CS projects [Chu, Leonard and Stevenson, 2012; Curtis, 2015; Evans et al., 2005; Land-Zandstra et al., 2015; Nov, Arazy and Anderson, 2014; Raddick et al., 2010; Reed et al., 2013; Rotman et al., 2012; Socientize, 2013]. Many participants become involved because they are excited to contribute to real scientific research or to an important cause such as the environment or health. Others are motivated because they find the topic of the project (e.g. birds, galaxies) interesting, or the activities fun. Some people see CS projects as a learning opportunity. Finally, people may join CS projects because they like to get in touch with people with the same interests and become part of a community. This social interaction can happen physically, through meetings, training and information sessions, or virtually through blogs and forums.

Instead of looking at motivation for CS as a static concept, several scholars have proposed to also consider how motivation changes over time and with different levels of contribution [Crowston and Fagnot, 2008; Eveleigh et al., 2014; Rotman et al., 2012]. For example, Rotman and colleagues [2012] use their citizen science involvement framework to show that new participants generally have egocentric motives to participate, where later on they are driven more by the desire to increase welfare of others. This framework is based on Batson et al.'s [2002] four categories of motives for involvement: (1) egoism, the goal to increase personal welfare; (2) altruism, the goal to increase someone else's welfare; (3) collectivism, the goal to increase a group's welfare; and (4) principlism, the goal to act in accordance with one or more moral principles. Similarly, Crowston and Fagnot [2008] suggest that initial contributors are mainly driven by a curiosity about the project, while sustained contributors are also motivated by social obligation, shared ideology with the project, and intrinsic factors such as a feeling of satisfaction about their contribution.

Learning impact

Many citizen scientists are interested to learn about the project's scientific topic, but are less motivated to learn about the scientific method [Brossard, Lewenstein and Bonney, 2005; Cronje et al., 2011; Jordan et al., 2011]. Previous studies have shown that CS projects can have an impact on both learning processes — albeit with varying success [Bonney et al., 2009a; Brossard, Lewenstein and Bonney, 2005; Crall et al., 2012; Druschke and Seltzer, 2012; Evans et al., 2005; National Research Council, 2009; Riesch, Potter and Davies, 2013; Trumbull et al., 2000]. How much a participant learns from a CS project depends on factors such as the level of interaction between the scientific staff and the participant, and how clear it is made to participants how their contributions relate to the scientific process [Crall et al., 2012; Evans et al., 2005]. In order to develop CS projects that can have an impact on the public's knowledge of the scientific topic and method, it is important to gain insight into how people learn from these projects.

The Great Influenza Survey

The Great Influenza Survey (GIS; "de Grote Griepmeting" in Dutch) is a Dutch CS project that started in 2003. Every year, thousands of people from the Netherlands and Flanders, the Dutch-speaking part of Belgium, report their symptoms to a central database. These symptoms are used to determine the rate of common cold and influenza-like illness (ILI) according to strict symptomatic criteria developed in collaboration with scientists [Marquet et al., 2006]. Data are available almost real time in maps and graphs on the project's website. Modelled after the Dutch project, several other countries worldwide have adopted similar projects [van Noort et al., 2015].

Systems like this that survey illnesses online through reports from the general public are also called "internet-based participatory surveillance" [Paolotti et al., 2014; Vandendijck, Faes and Hens, 2013; Wójcik et al., 2014]. Wójcik et al. [2014] reviewed that all of these participatory surveillance systems show a great similarity with national sentinel networks where general practitioners report influenza cases. Indeed, Dutch GIS data follow an almost identical course as the Dutch Sentinel Practice Network, with peaks in the same weeks [Marquet et al., 2006]. However, the GIS peaks are much higher on average, showing an incidence rate around five times higher than the sentinel networks. The proposed explanation is that data from GP sentinel networks mostly capture young children and the elderly, groups that are more likely to visit the doctor with flu-like symptoms, while GIS receives data from a broader group of people who might not all visit the doctor when they have symptoms [Marquet et al., 2006].

Besides the goal of providing a surveillance system for ILI, GIS was explicitly developed with an educational goal in mind. The developer (CEK) wanted to use an interactive science activity to make scientific information available to a broad public and to increase participants' interest in science. This goal is apparent in the ways that GIS recruits participants, keeps participants up to date, and communicates to the general public.

Participants are recruited through press releases, direct mailings to schools and universities and coverage of the project in popular media. Participants register by completing an in-take questionnaire asking them about demographic information, daily behavior (e.g. transportation, work), household composition, and pre-existing conditions (e.g. asthma). After registration, participants receive a weekly e-mail asking them to report their symptoms or the lack thereof. These e-mails contain a newsletter with flu-related news articles written by professional science journalists. The website provides participants as well as others who are interested access to the data through maps, graphs and tables. Throughout the season, program organizers try to increase curiosity and visibility by issuing press releases, showing up in local and national media and through their presence on social media platforms. These efforts have resulted in a participant base of around 12,000 participants each year, completing around 9,000 surveys weekly during the flu season (November–May). Participants are very loyal, with most people completing their survey almost every week.

Objective

Eveleigh et al. [2014] point out that motivation to participate may vary among different levels of contribution. Participants who sporadically submit data or analyze images, may have different types of motivation than people who contribute to a project on a regular basis. In addition, other scholars have proposed that motivation may change over time, as described above [Crowston and Fagnot, 2008; Rotman et al., 2012]. Crall et al. [2012] suggest that CS projects may attract a self-selected group of people who already possess advanced knowledge about science, which makes it harder to measure change over time. Looking at groups with different levels of previous experience with scientific research or citizen science may show differences.

Therefore, the purpose of the current study was (1) to identify primary motivations of this active and loyal population of Great Influenza Survey participants; (2) to evaluate their self-reported learning impact; (3) to measure their knowledge about the flu and the project; (4) to gain insight in the differences in motivation and learning between new and sustained contributors and (5) between more and less engaged contributors; and (6) to gain insight in differences in motivation and learning impact between contributors with and without previous experience with (citizen) science.

Methods

Data Collection

An online survey was conducted in February and March of 2014 consisting of around 40 multiple choice and Likert-scale questions about several topics: demographics, previous experience, engagement in the project, motivation, perceived learning impact and knowledge of flu and the project (see S1 for a complete list of questions). The questionnaire was similar to the questionnaire of a previous study with a different CS project [Land-Zandstra et al., 2015], with questions about motivation partly based on the list of motivations of Galaxy Zoo participants [Raddick et al., 2013]. Furthermore, respondents' knowledge of flu and the project was measured with true/false statements, similar to [Brossard, Lewenstein and Bonney, 2005]. All Likert-scale questions were measured on a 5-point scale ranging from not at all applicable (1) to totally applicable (5). One limitation of this data collection method is that it results in self-reported data about motivation and learning impact. This could have introduced some bias to our data [Jensen, 2014]. However, when direct measurement of these constructs is impossible, many CS studies have used self-reported data collection methods as a second best [Bonney et al., 2009a; Brossard, Lewenstein and Bonney, 2005; Crall et al., 2012; Raddick et al., 2013; Reed et al., 2013; Trumbull et al., 2000].

Respondents were recruited through an invitation in the weekly newsletter of the Great Influenza Survey and through the Facebook page of the project. A reminder was sent four weeks after the initial invitation, doubling the response to 1771 people. With around 12,000 registered flu reporters, this resulted in a response rate of 15%. This rather low response rate [Cook, Heath and Thompson, 2000] could be caused by the fact that the questionnaire was conducted late in the flu season and that the 2013–2014 season showed a low flu incidence rate. However, comparison of demographic data showed that this sample is typical for the entire population of flu reporters (see below). After cleaning up the data file and removing respondents who had not completed the entire questionnaire, a sample of 1610 respondents remained.

Participants

Of our sample, 63 percent were female, which was comparable to the entire population of flu reporters (56% female). In our sample, the average age was 57 with a range from 20 to 92. The age distribution of the sample was similar to the age distribution of all flu reporters (Figure 1). However, both the project as a whole and the current study have a rather low response rate in the age group below 30 years old, while the age groups between 45 and 74 are overrepresented. In terms of daily routine, the largest group of respondents are retired (30%), followed by full time (25%) and part time employees (20%). Compared to the entire Great Influenza Survey population, retired people are overrepresented and people with jobs are underrepresented (Figure 1). The distribution of education levels of study participants and the GIS population are quite similar (Figure 1). More than half of all respondents have finished either a bachelor's or a master's degree.

For 56% of respondents this project was the first time they joined a CS project. Respondents who did have previous CS experience, reported projects such as the national yearly bird count, other surveillance systems (pneumonia), or distributed computing projects. In addition, 61% of respondents had previous experience with scientific research, either as a researcher, student or volunteer. In terms of previous experience with science in their daily lives, most respondents reported to read news items about science ($M = 4.05$, $SD = 1.05$; on a 5-point Likert scale) and to watch TV shows about science ($M = 3.88$, $SD = 1.06$). Other activities such as going to scientific lectures ($M = 2.57$, $SD = 1.46$), following science news on social media ($M = 2.61$, $SD = 1.42$), and donating money to scientific research ($M = 2.76$, $SD = 1.43$) were uncommon. Some people read science magazines ($M = 2.93$, $SD = 1.45$) and agree that they use scientific knowledge in their daily lives ($M = 3.35$, $SD = 1.31$).

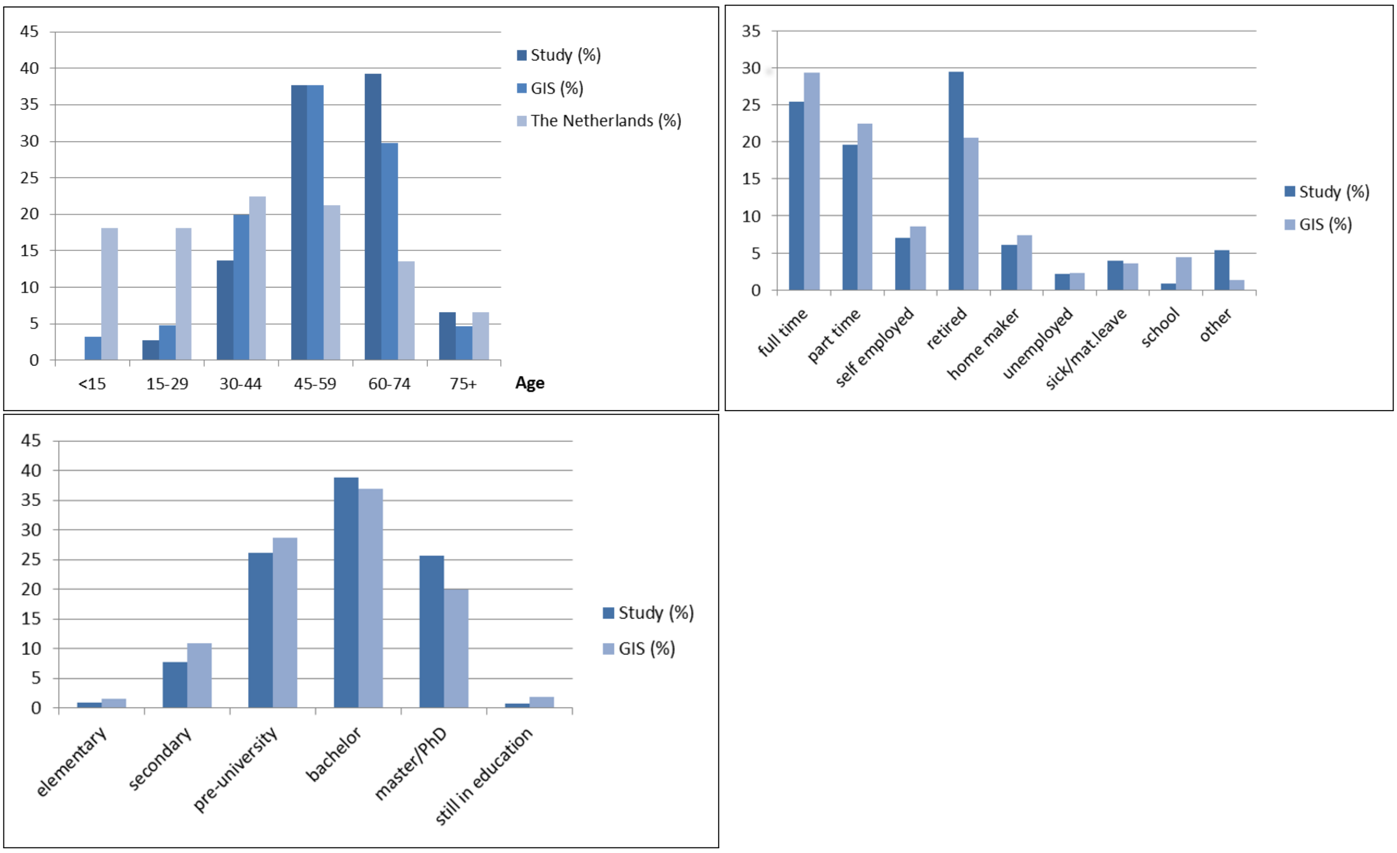

Figure 1. Comparison of demographics of study sample vs Great Influenza Survey population.

Data Analysis

Data were analyzed descriptively to determine characteristics of the GIS sample. In addition, principal component analysis (PCA) was performed to determine if the motivation data could be grouped together in a few components. Differences among groups were analyzed using correlational analyses (Spearman Rho since Kolmogorov-Smirnoff analysis determined that most data were not normally distributed), t tests and analyses of variance (ANOVA). All significance levels were set at $\alpha = .05$ unless stated otherwise. Analyses were performed using SPSS version 21.

Results

Engagement in the Great Influenza Survey

During the flu season from November 2013 until May 2014, flu reporters were invited to report their flu symptoms or the lack thereof. Of all respondents, over 82 percent self-reported to submitting their symptoms on a weekly basis. Sixteen percent completed the survey a few times a month and only two percent of respondents completed the survey less than once a month (Figure 2). These numbers are similar to the actual activity on the Great Influenza Survey, measuring 73% of participants who completed the survey more than twenty times during the season of 2013–2014 (29 weeks of surveying) and 68% of flu reporters whose completed surveys were less than nine days apart. In addition, the majority of this study's respondents had been participating in the project for several years. Sixteen percent joined at the start, eleven years prior to the current study, 27% had been part of the project for five to ten years, 52% joined two to five years ago, 2% had been involved for one year and for 3% this was their first season.

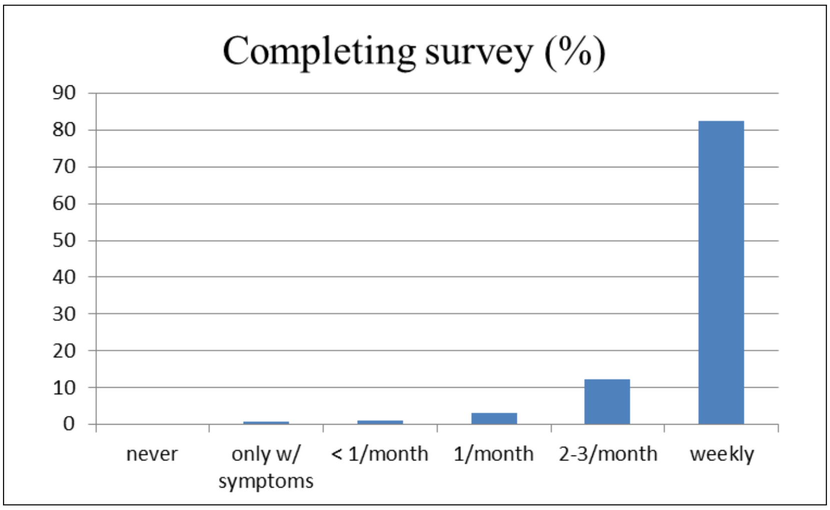

Figure 2. Self-reported frequency of completing weekly survey.

Motivation

Motivation to participate was measured through a list of 13 Likert-scale statements asking about the importance of each motivator and one question where respondents had to pick the most important reason. The most important reasons were contribution to knowledge about flu (38%), contribution to science (19%) and contribution to the GIS project (16%). Least important reasons were learning about flu (0.7%), interest in flu (0.6%) and use in school (0.2%).

Principal Component Analysis was performed on the Likert-scale items about motivation. PCA revealed three components with eigenvalues greater than one (Kaiser's criterion) which were labeled *contribution*, *interest in science*, and *self-interest*, explaining 40%, 14%, and 9% of total variance respectively. All three scales show good reliability (0.79, 0.80, and 0.74, respectively; [Kline, 1999]). Table 1 shows that *contribution* scored highest ($M = 4.59$; $SD = 0.57$) followed by *interest in science* ($M = 4.15$; $SD = 0.68$) and *self-interest* ($M = 3.62$; $SD = 0.84$). Women scored significantly higher on all three scales ($t(995) = 2.96$, $t(1094) = 3.69$, $t(1608) = 3.91$, $ps < .01$). In addition, older people scored slightly higher on the *contribution* scale ($r_s = .088$, $p < .01$) and the *interest in science* scale ($r_s = .073$, $p < .01$).

Learning Impact

Respondents indicated on a 5-point Likert scale if they thought they had learned something through their participation in the GIS project. They agreed to having learned about the GIS project itself ($M = 4.02$; $SD = 0.86$), flu ($M = 3.86$; $SD = 0.98$), epidemics ($M = 3.70$; $SD = 0.98$), science ($M = 3.34$; $SD = 0.97$) and their own health ($M = 3.25$; $SD = 1.10$). Men were significantly more inclined to agree to having learned about the flu than women ($t(1285) = 2{,}46$, $p < .05$). No other differences

Table 1. Motivation to participate in the Great Influenza Survey.

Scale and Items	Mean (SD)	Reliability (α)
Contribution	4.59 (0.57)	0.81
Contribution to knowledge about flu	4.71 (0.63)	
Contribution to science	4.59 (0.71)	
Contribution to GIS project	4.55 (0.73)	
Important to get as many measurements as possible	4.51 (0.79)	
Interest in science	4.15 (0.68)	0.80
Interested in health	4.40 (0.76)	
Interested in science	4.26 (0.86)	
Interested in GIS project	4.16 (0.86)	
Interested in flu	3.77 (0.95)	
Self-interest	3.62 (0.84)	0.74
I like to help	3.97 (0.96)	
Fun to do	3.68 (1.08)	
Being part of community of flu-reporters	3.63 (1.17)	
Keeping track of my own health	3.20 (1.25)	

Note. N = 1610.

existed between genders. Older respondents were more likely to report a learning impact on knowledge about science, the GIS project, and epidemics (r_s = 0.12, r_s = 0.09, r_s = 0.08, $ps < .01$).

We also determined respondents' knowledge about the flu and about the GIS project with a series of true/false statements (20 and 12 questions, respectively, see Table 2). On average, respondents answered 90% of the questions correctly, with 92% on questions about the project and 89% on questions about flu. No significant differences existed between men and women. Significant correlations existed between age and number of correct answers. Older people tended to score lower on knowledge about flu, knowledge about the project, and total knowledge (r_s = 0.15, r_s = 0.21, $r_s = 0.22$, $p_s < .001$).

Duration of participation

ANOVA analyses were performed to determine if differences existed among groups of people with a different duration of their participation in the project (see Table 3 for significant results). Respondents indicated the duration of their participation through the following categories: *first time participants, 1 year, 2–5 years, 5–10 years, from the start* (see S2 for a frequency distribution of the sample). First, in terms of knowledge, no significant differences existed between duration groups. However, we did find significant differences among groups in terms of self-reported learning impact on knowledge about flu and about epidemics. Respondents who were part of the GIS project from the beginning were significantly more likely to report having learned about flu than respondents who were participating for the first year. Similarly, respondents from the groups *2–5 years*, *5–10 years*, and *since the beginning* all scored higher on learning about epidemics than first-year respondents. Post hoc analyses showed that respondents who joined the project from the start scored significantly higher on both *contribution* and *interest in science* as motivating factors than first time participants.

Table 2. Knowledge about flu and the GIS project.

Questions	Correct (%)
About Flu	
Several flu viruses exist that can change (true)	99
Flu is the same as the common cold (false)	99
The composition of the flu vaccine can change every year (true)	99
Flu is only contagious when you have developed a fever (false)	97
Flu vaccination keeps you from getting the flu (false)	97
Flu is caused by a virus (true)	97
You can only get the flu when you touch someone with the flu (false)	96
Flu is not the same as the common cold, symptoms develop quicker and are often more severe (true)	96
Flu can spread through drops of saliva of infected people (true)	95
Flu can spread through shaking hands or kissing (true)	93
Flu is not contagious (false)	92
You cannot die from the flu (false)	92
Flu is caused by bacteria (false)	91
You can decrease the chance of infection by washing your hands regularly (true)	90
Flu vaccination results in a lower chance of getting the flu (true)	90
Flu can spread through the air (true)	89
There is no vaccination against the flu (false)	80
Flu can spread through surfaces of door knobs and keyboards (true)	77
You can get flu by inhaling as little as three flu particles (true)	72
Influenza is an acute infection of the upper airways (true)	43
Total Flu	**89**
About GIS	
Measurements of GIS show how flu spreads over the Netherlands and Belgium (true)	99
It is important that as many people as possible, spread out over the entire country, complete the flu survey (true)	99
It is important to complete the flu survey regularly, even if you don't have symptoms (true)	99
If you don't have any symptoms, you don't need to submit the survey (false)	98
If several countries perform flu surveys, we can predict how flu spreads internationally (true)	97
With the provided table, determine in which month the flu was at its peak	96
It doesn't matter how many people complete the flu survey (false)	95
With the symptoms you submit, GIS determines if you are likely to have influenza (true)	92
On the provided map, how did the flu spread during the season?	89
With all the measurements, GIS can predict how the flu will spread in the future (true)	87
With all the measurements, GIS can determine when the flu will start next year (false)	87
With the symptoms you submit, GIS determines if you have influenza (false)	68
Total GIS	**92**
Total	**90**

Note. N=1610

Table 3. Differences in motivation, knowledge, and learning impact across levels of duration, engagement, and prior experience.

	Duration			Engagement							Prior experience			
				Submit			Consult			Info	Research		CS	
	$df_{between}$	df_{within}	F	$df_{between}$	df_{within}	F	$df_{between}$	df_{within}	F	r	df	t^a	df	t^a
Motivation														
Contribution	4	1605	4.08**	3	1606	4.49**				.12***				
Interest	4	1605	3.56**				4	1605	20.18***	.26***	1483	3.79***	1608	2.83**
Self-interest							4	1605	13.94***	.16***	1608	−7.28***		
Learning														
flu	4	1601	4.15**				3	1602	29.48***	.34***				
epidemics	4	1601	4.34**				3	1591	29.53***	.33***	1593	−2.68**		
own health							3	1590	10.28***	.17***	1592	−5.68***		
GIS project							3	1591	24.04***	.29***	1593	−2.13*	1593	2.59*
science							3	1584	22.01***	.30***	1586	−4, 57***		
Knowledge														
flu				3	1531	3.92**	3	1531	6.96***		1369	6.59***		
GIS project				3	1577	6.11***	3	1577	11.65***		1579	5.33***		
total				3	1507	7.07***	3	1507	11.69***		1367	8.08***		

* $p < .05$, ** $p < .01$, *** $p < .001$. [a] Negative *t*values indicate instances where the group without experience scored higher than the group with experience.

Levels of engagement

Besides looking at different duration of respondents' participation, we also analyzed differences across levels of engagement. We determined levels of engagement in terms of the frequency of data submission of the respondents, the frequency of data consulting, and how often they used the newsletter, the website, the forum, and social media to get information about the flu and about the project (see S3 for frequency distributions of the sample). Table 3 shows the significant results for all comparisons.

First, we looked at levels of data submission: *less than once a month, once a month, 2–3 times a month, weekly*. Respondents who submitted data 2–3 times a month or weekly scored significantly higher on *contribution* as a motivating factor than respondents who contributed less than once a month. There were no significant differences with regard to self-reported learning impact. However, there were significant differences with regard to knowledge about flu and about the project. Post hoc analyses revealed an interesting pattern. Respondents from the 2–3 times a month *group* scored higher than respondents from *once a month* group and the *every week* group. This pattern decreased, but remained when controlling for age as a confounding variable.

Second, we looked at differences across levels of data consulting: *never, a few times a year, every month, every week*. Significant differences existed across the four levels of data consulting on scales *interest in science* and *self-interest*. Post hoc analyses showed that respondents who consulted data more often, scored higher on the *interest in science* scale, with all but the difference between *a few times a month* and *monthly* and between *monthly* and *weekly* being significant. Data for the *self-interest* scale showed a similar trend with significant differences between the *weekly* group and all other groups.

The self-reported learning impact showed similar trends across the four levels of data consulting for all topics with practically all differences being significant. Overall, respondents who consulted data more often also reported higher learning gains. With regard to knowledge scores across the same four levels of data consulting, people from the *a few times a year* group scored higher than all other groups. Controlling for age resulted in a similar pattern, albeit with smaller differences.

Third, we determined if relationships existed between actively looking for information and motivation, learning impact and knowledge. A combined variable for information seeking consisted of reading the newsletter, looking up other information on the project's website, interacting on the project's forum and reading the project's Facebook page, ranging from 0 (never) to 6 (extensively). With regard to their motivation, people who looked at information from the project more often, tended to score higher on all three categories of motivation: *interest* ($r_s = .26$, $p < .001$), *self-interest* ($r_s = .16$, $p < .001$) and *contribution* ($r_s = .12$, $p < .001$).

In addition, significant relationships existed between information seeking and self-reported learning impact for all five topics. People who were more active in finding information in the newsletter, on the website, the forum and the Facebook page, reported to having learned more. Surprisingly, information seeking did not correlate with the scores on the knowledge questions.

Prior Experience

As Crall et al. (2012) suggested, CS projects may attract a self-selected group with previous knowledge and experience with CS or with scientific research, making it harder to determine a learning impact over time. Therefore we looked at differences between respondents who did have experience with scientific research and CS and respondents who did not have these experiences (see S4 for frequency distribution of the sample; see Table 3 for significant results). First, chi square analysis showed that people with experience in scientific research more often picked contribution to scientific research as the most important reason for participation ($\chi^2(14, 1610) = 60.96$, $p < .001$). They picked contribution to the GIS project and because it is fun to do less often as the most important reason. In addition, respondents with experience in scientific research scored significantly higher on the *interest in science* scale for motivation and significantly lower on the *self-interest* scale. In terms of self-reported learning impact, respondents with previous experience with scientific research learned significantly less than respondents with no previous experience on all topics except flu. Similarly, people with experience in scientific research scored higher on the knowledge questions than people without research experience.

Second, respondents who had previous experience with CS scored significantly higher on the *interest* scale than people without CS experience. Respondents with CS experience self-reported to having learned more about the GIS project than people without CS experience. No significant differences existed between these groups in terms of knowledge about the flu and about the project.

Discussion

As many CS projects show high attrition rates and low activity of the majority of participants, it is important to learn more about what motivates people to join a CS project and to stay with it. In this study, we looked at motivation and learning impact of participants of the Dutch Great Influenza Survey, a project with a loyal and active participant base. We found that most participants were primarily motivated by the desire to contribute (to knowledge about flu, to science). Although learning is one of the least important reasons for participation, respondents believed they learned something through their participation about the project itself and about the relevant health topics (flu, epidemics). The majority of participants had a good basic knowledge about flu and about how the project worked. Looking at different levels of duration, engagement and prior experience, first we found that people who had been part of the project for a longer period of time were more motivated by the opportunity to contribute to science and by an interest in health and science. They also reported a larger learning impact about flu and epidemics. Second, people who were more actively involved in the project through consulting of the data and accessing information through the project's newsletter and website showed larger motivation and learning impact. Third, people with previous experience in scientific research showed higher scores for interest in health and science as a motivator and lower scores for self-interest (doing it for their own good or just for fun).

Motivation

Clearly, contribution was a major motivator for participants of the GIS project. Reasons related to contribution were more applicable to the participants than reasons related to interest (in flu, health, the project) or self-interest (record own health, fun activity). In particular, when respondents had to pick the most important reason, contribution to knowledge about health, to science, and to the project were the top motivators. These findings are in line with many other studies of CS projects [Curtis, 2015; Dickinson et al., 2012; Land-Zandstra et al., 2015; Newman et al., 2012; Nov, Arazy and Anderson, 2011b; Nov, Arazy and Anderson, 2014; Raddick et al., 2013; Reed et al., 2013]. However, although reasons such as enjoyment of the activity and social engagement can be important reasons for participation in other CS projects [Dickinson et al., 2012; Jennett et al., 2013; Reed et al., 2013; Tinati et al., 2015], they were not particularly important to GIS participants. Possibly, the type of project makes a difference here. Participating in the GIS is something that can be easily done individually, without any interaction with fellow participants. Unlike projects that include going outdoors to explore and record observational data in nature, here, the activity itself, i.e. filling in a short survey, is not necessarily enjoyable in its own sake. There are other (virtual) CS projects that report a solitary experience as preferable for participants [Eveleigh et al., 2014].

Another interesting finding is that GIS was able to attract many people without previous experience with scientific research, citizen science, or science activities in their daily lives. This finding suggests that a CS project like GIS is able to get people in touch with science, contradicting previous findings that CS participants may be a self-selected group with previous experience with and interest in science [Crall et al., 2012]. One way the GIS project reaches out to current and potential participants is by appearing frequently in mainstream media and by having a well-known science communicator serve as the ambassador of the project (CEK). In some other countries who have adopted the same project (internationally called Influenzanet[1]), the scientists leading the project are having trouble reaching the general public. In 2006, in Portugal for example, directly after a lecture by a science communicator and an appearance in a television talkshow by the lead organizer, the number of participants increased substantially. The importance of (social) media presence is also clear from the success of the Australian project Flutracking.[2] In this project, that is funded by the Commonwealth Department of Health, media releases, social media and word-of-mouth are important channels to reach new participants [Dalton et al., 2015]. Flutracking in Australia has similar loyal participants to the Dutch GIS project with on average 24,000 of the 27,000 participants responding each week. A more in-depth and systematic evaluation of all these different flu tracking projects is needed to reveal specific factors that contribute to their success, including media attention, the topic of flu, weekly reminders, and cultural differences.

Learning Impact

Although most participants did not join the GIS project with the goal to learn about flu or science, they did agree that they learned something about the project, about

[1] www.influenzanet.eu.
[2] www.flutracking.net.

flu, epidemics, science, and their own health. These findings underline the idea that CS projects can play a role in science learning of the general public [Bonney et al., 2009b; Brossard, Lewenstein and Bonney, 2005; Crall et al., 2012; Evans et al., 2005; National Research Council, 2009; Riesch, Potter and Davies, 2013; Trumbull et al., 2000].

In addition, participants scored high on knowledge questions about flu and about the project. Unfortunately, no baseline information was available in this study to determine if these high scores were the result of a learning effect. However, we were able to compare scores for different groups of participants in terms of learning impact as well as motivation.

Differences among groups

Duration. First, we looked at groups of participants who had been part of the project for different amounts of time. People who had joined the project from the start, eleven years before the moment of this study, scored significantly higher on *contribution* and *interest in science* than first-time participants. Although we did not collect data longitudinally to determine change in motivation, the fact that long-time participants are more motivated by a drive to contribute to a bigger cause is in line with the framework of Rotman et al. [2012]. However, *contribution* was the most important motivator for the entire sample, including beginning participants. In addition, *self-interest* was the least important reason for the entire sample, and there was no significant difference between long-term versus short-term participants. These findings may indicate that a trend as proposed by Rotman et al. [2012] is absent in this project. However, we need to be careful when interpreting these differences among groups. Instead of a change over time, people who are more motivated or whose interests and ideas align with the GIS project may be the participants who stay with it longer [Crowston and Fagnot, 2008]. Longitudinal data needs to be collected in order to determine how motivation of GIS participants develops over time.

We also found that participants who had been part of the GIS project for longer reported a larger learning impact about flu and epidemics than beginning participants. However, measured through the knowledge questions on the questionnaire, understanding about flu was high for all groups. Longer-term participants have gone through several flu seasons, including the swine flu pandemic during the season 2009–2010. During each season they have experienced different types of flu trends with accompanying explanations and reports in the newsletter, on the website and through other media outlets. This may have added to the perceived impact on their knowledge and understanding about flu and epidemics. The questions on the questionnaire measuring participants' level of understanding of flu may have resulted in a ceiling effect, making it difficult to measure a difference among duration groups. In addition, we cannot be sure if the high knowledge scores of all participants were caused by their involvement with GIS. Because learning about science is an important goal of many CS projects, it is important to incorporate the collection of baseline data within the project design, for example at registration [Druschke and Seltzer, 2012]. This will make the collection of longitudinal data possible at a later time, which in turn will help determine the impact of CS projects.

Engagement. Second, we looked at different levels of engagement to see if more engaged participants showed different motivation and learning impact than participants who were less engaged. Eveleigh et al. [2014] state that intrinsically motivated participants are more likely to engage in more in-depth or varied CS activities. However, in the GIS project there is one type of data contribution, i.e. submitting the weekly survey about flu-like symptoms. Ways for flu-reporters to get more engaged in the project are through consulting the data online, through looking at information in the newsletters or the website and by interacting through the forum and Facebook.

Participants who were more active in submitting their weekly surveys scored higher on *contribution* as a motivator, but not on *interest in science* or *self-interest*. Although we cannot conclude that the type of motivation is the cause for a larger contribution to the project, this finding underlines again the importance for participants to know that they are contributing to a real cause [Land-Zandstra et al., 2015; Nov, Arazy and Anderson, 2011b; Raddick et al., 2013; Reed et al., 2013]. There were no differences in learning impact among different levels of data submission. However, knowledge scores showed a peak for people who submitted data two to three times a month compared to people who submitted data once a month or on a weekly basis. Although, older people were underrepresented in this group, increasing the average knowledge score, this pattern remained after controlling for age. Possibly, people who submit data every week have developed an automatic response and make a less conscious decision to submit data resulting in lower knowledge scores.

We also looked at different levels of engagement in terms of how often participants consulted the data on the website. Many CS researchers mention the importance of feedback of CS results to the participants [Bonney et al., 2009b; Cooper et al., 2007; Devictor, Whittaker and Beltrame, 2010; Eveleigh et al., 2014; Nov, Arazy and Anderson, 2014; Silvertown, 2009]. In our sample, about half of the participants consulted the results of GIS online on a regular basis (monthly or weekly), and only ten percent did not look at the results at all. People who were more active in consulting the data reported a larger learning impact. The fact that data are available in many different formats (tables, figures, maps) and that users can choose many different aspects of the data that were collected (demographics, activity levels, spread of the flu epidemic over the country, comparing different countries, different seasons) may add to the learning impact. In addition, in terms of motivation, *interest in science* and *self-interest* as motivating factors were higher for groups of participant that consulted the data more often while no difference was found for *contribution*. Possibly, participants who are interested in flu, the science behind the flu, and the project itself, are more likely to look up results that contribute to these interests. In addition, people who are interested in their own health record will probably look at the results more often. Knowledge scores were significantly different among groups with different levels of data consulting. Interestingly, participants who consult data a few times a year scored higher than all other groups, even the groups that consult data monthly or weekly. Although age did have some influence, the pattern remained after controlling for age. More in-depth research is needed to explain these findings.

Levels of engagement were also determined in terms of information-seeking behaviour. Participants who were more active in accessing information about flu and the project through the newsletter, the internet, the forum and social media scored higher on all three scales of contribution and on all five topics of learning impact than participants who were less actively looking for information. Apparently, these people were more enthusiastic about the project on all aspects and put more effort in learning about flu and the project. However, no significant differences existed in knowledge scores among these groups, possibly caused by a ceiling effect.

Prior experience. Third, we looked at differences in learning impact and motivation between groups with and without prior experience in scientific research and citizen science. Participants who had prior experience in scientific research, either as a student, as a career, or as a volunteer more often picked contribution to scientific research as the most important reason and less often picked because it is fun. Apparently, participants with experience in scientific research were more serious about their participation in another scientific study. Possibly, they are able to appreciate the importance of contribution of data to a scientific study. In addition, participants with experience in research reported a lower learning impact than people with no experience. Possibly, because of their prior involvement in (health) research they do not expect to learn a lot from a CS project. Their knowledge was significantly higher than the knowledge of people without research experience.

Prior experience in CS was not associated with many other variables, except for *interest in science* as a motivator and the learning impact about the GIS project. This latter finding corresponds with Eveleigh et al.'s [2014] suggestion that first time users are more driven by curiosity than sustained participants. This may explain why first time CS participants are more likely to agree that they learned something about the project.

Implications

Just as for many other CS projects, the desire to contribute to scientific research and to knowledge about flu appeared to be a major motivator in this study [Dickinson et al., 2012; Land-Zandstra et al., 2015; Newman et al., 2012; Nov, Arazy and Anderson, 2011b; Nov, Arazy and Anderson, 2014; Raddick et al., 2013; Reed et al., 2013]. This makes it key to address contribution as a motivating factor in all aspects of the project and to all participating groups. To attract new participants, messages should include the importance of their contribution to science. But also for sustained participants, it should be clear that their continued contributions are valued. In the GIS project this is done through mentioning the participants' contribution in many of the press releases and media outlets. At the start, but especially during, the flu season, GIS organizers send out regular press releases about the flu and how the projects' data can help interpret the course of the flu. Those press releases always include the contribution of flu-trackers. An interesting comparison can be made with a flu-tracking project in the United States called Flu Near You,[3] where the project is framed as a way to know when the flu is present in your area, a

[3] https://flunearyou.org/.

more egocentric message than GIS's emphasis on the contribution that participants are making to knowledge about flu and to science in general. In light of our findings that participants are more motivated by altruistic than egocentric reasons, the difference in the framing of the message may explain purported low attrition levels of Flu Near You participants. However, we should be very cautious with these kinds of comparisons, and further research is needed to substantiate them.

In addition, the accumulated data of all GIS participants are available on the website of the project. Participants are able to see how the work of all participants is contributing to an understanding of flu trends through the Netherlands and Flanders and of differences in flu incidence among different demographic groups. However, in a future study, individual or focus group interviews with different types of contributors (including dropouts) could shed light on what features of the GIS project make it so successful in attaining participants and in motivating participants to submit data every week.

Another implication is that the availability of information in newsletters, on the website, and the availability of the accumulated data online can help increase the learning impact of a CS project. The majority of GIS participants read news articles in the newsletter at least once a month. These news articles are written by professional science writers who have experience in popularizing scientific information for the general public. In fact, the entire GIS project was started as an activity to allow the public to get in touch with real science and be part of a scientific study about flu. Initially, the surveillance system for influenza-like-illness was of secondary importance. When learning about science is an important goal of a CS project, efforts should be made to provide participants with a variety of ways to learn about the project and the science behind it [Crall et al., 2012; Evans et al., 2005].

Finally, we propose that the collection of baseline data about participants' motivation and knowledge about the scientific topic as well as about the scientific process should be part of the design of any CS project. In order to further the field of research about the impact that CS can have on participants' motivation and knowledge, we need to be able to gather data longitudinally. Including a short questionnaire at the moment of registration may increase the possibility to measure impact of a CS project at a later moment [Druschke and Seltzer, 2012].

Translating these implications into recommendations for similar CS efforts, we suggest that project organizers seek (social) media attention regularly, preferably linking their message to current events. It may help when this public communication is done by a (well-known) science communicator as the ambassador for the project. Current participants should be kept informed about the project on a regular basis as well, for example through newsletters. For both types of information it is important to emphasize how CS participants have contributed to the findings and the success of the project. It is smart to include professional science writers in the project team, who are able to communicate the science behind the project effectively to a general public. And finally, in order to advance the field of CS research, including the collection of baseline data should be included during registration.

Supplemental Material

S1 — Questionnaire (translated from Dutch)

How long have you participated in the GIS project?
How often do you enter data during the flu season?
How often do you read the news articles in the newsletter?
How often do you look at results (graphs and overviews) on the GIS website?
How often do you read other information on the GIS website?
Do you follow the forum on the GIS website?
Do you follow GIS on Facebook?
I participate in the GIS

- because I want to contribute to science
- because I want to contribute to knowledge about flu
- because I want to contribute the GIS project
- because I am interested in science
- because I am interested in health
- because I am interested in flu
- because I am interested in the GIS project
- because it is important to get as many measurements as possible
- because I enjoy to be part of the community of flu-reporters
- because I want to keep track of my own health
- because I want to use the GIS in education
- because I think it is fun to do
- because I like to help
- I participate for a different reason, that is...

What reason to participate is most important to you?
Because of my participation in the GIS project, I learned more about flu

- bout epidemics
- about my own health
- about the GIS project
- about science

Statements about flu. True or false?

- Several flu viruses exist that can change
- Flu is the same as the common cold
- The composition of the flu vaccine can change every year
- Flu is only contagious when you have developed a fever
- Flu vaccination keeps you from getting the flu
- Flu is caused by a virus
- You can only get the flu when you touch someone with the flu
- Flu is not the same as the common cold, symptoms develop quicker and are often more severe
- Flu can spread through drops of saliva of infected people
- Flu can spread through shaking hands or kissing
- Flu is not contagious
- You cannot die from the flu
- Flu is caused by bacteria
- You can decrease the chance of infection by washing your hands regularly Flu vaccination results in a lower chance of getting the flu
- Flu can spread through the air
- There is no vaccination against the flu
- Flu can spread through surfaces of door knobs and keyboards You can get flu by inhaling as little as three flu particles
- Influenza is an acute infection of the upper airways

Statements about the GIS. True or false?

- Measurements of GIS show how flu spreads over the Netherlands and Belgium
- It is important that as many people as possible, spread out over the entire country, complete the flu survey
- It is important to complete the flu survey regularly, even if you don't have symptoms
- If you don't have any symptoms, you don't need to submit the survey
- If several countries perform flu surveys, we can predict how flu spreads internationally
- It doesn't matter how many people complete the flu survey
- With the symptoms you submit, GIS determines if you are likely to have influenza
- With all the measurements, GIS can predict how the flu will spread in the future
- With all the measurements, GIS can determine when the flu will start next year
- With the symptoms you submit, GIS determines if you have influenza
- Refer to the above figure. In season 2012–2013, when was the peak of the influenza wave?
  - December
  - January
  - February
  - April
- Refer to the above figure. According to these maps, how did the influenza wave move?
  - Randomly, no pattern
  - From south to north
  - From north to south
  - I do not know

Have you participated in one of the following projects?

- Garden bird count
- Garden butterfly count
- Galaxy Zoo
- Distributed computing, such as SETI@home
- Natuurkalender.nl
- Gekaaptebrieven.nl
- iSPEX
- Great Nano-study
- Great Pneumonia Survey
- Tick radar or mosquito radar
- I participate(d) in a different citizen science project

Do you have experience with doing science?

- I do/have done scientific research as a high school student
- I do/have done scientific research as a college student
- I am/have been a scientific researcher
- I am/have been involved in scientific research as a volunteer

If yes, in which area(s) was that?

- Exact sciences
- Social sciences

Humanities
Medicine
Other
Not applicable

To what extent are these statements applicable to you?

I read news articles about science
I read popular science magazines
I watch TV-shows on scientific topics
I sometimes go to a lecture or gathering on a scientific topic
I follow news on science via social media
I sometimes donate money to scientific research
I use knowledge on scientific topics in my daily life

To what extent do you agree with the following statements?

Science and technology make our lives healthier
Science and technology make our lives easier
Science and technology could play a role in improving the environment

To what extent do you agree with the following statements?

I have faith in the objectivity of scientist
I expect that scientists sometimes manipulate their data to get the desired results

What is your year of birth?
What is your gender?
What are the four digits of your zip code?
In which country do you live?

the Netherlands
Belgium

What is the highest level of education you followed?
What is your primary occupation during the day?

I work full-time as an employee
I work part-time as an employee
I work as an entrepreneur
I am a student
I am a homemaker
I am unemployed
I am home due to a long-term illness or maternity leave
I am retired
Other, that is. . .

In what field do you work?

Science
Technique
Health
Other

S2 — Frequency distribution of duration of participation of the GIS sample

Duration	N	%
First time	51	3.2
1 year	38	2.4
2–5 years	831	51.6
5–10 years	431	26.8
From the start (11 years)	259	16.1
Total	1610	100

S3 — Frequency distributions of levels of engagement of the GIS sample

Data submission	N	%
Less than once a month	33	2.0
Once a month	50	3.1
2–3 times a month	200	12.4
Every week	1327	82.4
Total	1610	100

Data consulting	N	%
Never	166	10.3
A few times a year	669	41.6
Monthly	403	25.0
Weekly	372	23.1
Total	1610	100

S4 — Previous experience in (citizen) science of the GIS sample

Previous experience	N	%
With citizen science	771	44.2
With scientific research	622	38.6

Note. N = 1610

References

Batson, C. D., Ahmad, N. and Tsang, J.-A. (2002). 'Four Motives for Community Involvement'. *Journal of Social Issues* 58 (3), pp. 429–445. DOI: 10.1111/1540-4560.00269.

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., J., S. and Wilderman, C. C. (2009a). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Washington, D.C., U.S.A.: Center for Advancement of Informal Science Education (CAISE).

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V. and Shirk, J. (2009b). 'Citizen Science: a Developing Tool for Expanding Science Knowledge and Scientific Literacy'. *BioScience* 59 (11), pp. 977–984. DOI: 10.1525/bio.2009.59.11.9.

Brossard, D., Lewenstein, B. and Bonney, R. (2005). 'Scientific knowledge and attitude change: the impact of a citizen science project'. *International Journal of Science Education* 27 (9), pp. 1099–1121. DOI: 10.1080/09500690500069483.

Chu, M., Leonard, P. and Stevenson, F. (2012). 'Growing the Base for Citizen Science: Recruiting and Engaging Participants'. In: Citizen Science: Public Participation in Environmental Research. Ed. by J. L. Dickinson and R. Bonney. Ithaca, NY, U.S.A.: Cornell University Press, pp. 69–81.

Cook, C., Heath, F. and Thompson, R. L. (2000). 'A Meta-Analysis of Response Rates in Web- or Internet-Based Surveys'. *Educational and Psychological Measurement* 60 (6), pp. 821–836. DOI: 10.1177/00131640021970934.

Cooper, C. B., Dickinson, J., Phillips, T. and Bonney, R. (2007). 'Citizen science as a tool for conservation in residential ecosystems'. *Ecology and Society* 12 (2), p. 11. URL: http://www.ecologyandsociety.org/vol12/iss2/art11/.

Crall, A. W., Jordan, R., Holfelder, K., Newman, G. J., Graham, J. and Waller, D. M. (2012). 'The impacts of an invasive species citizen science training program on participant attitudes, behavior, and science literacy'. *Public Understanding of Science* 22 (6), pp. 745–764. DOI: 10.1177/0963662511434894.

Cronje, R., Rohlinger, S., Crall, A. and Newman, G. (2011). 'Does Participation in Citizen Science Improve Scientific Literacy? A Study to Compare Assessment Methods'. *Applied Environmental Education & Communication* 10 (3), pp. 135–145. DOI: 10.1080/1533015X.2011.603611.

Crowston, K. and Fagnot, I. (2008). 'The motivational arc of massive virtual collaboration'. In: *Proceedings of the IFIP WG 9.5 Working Conference on Virtuality and Society: Massive Virtual Communities*.

Curtis, V. (2015). 'Motivation to Participate in an Online Citizen Science Game: a Study of Foldit'. *Science Communication* 37 (6), pp. 723–746. DOI: 10.1177/1075547015609322.

Dalton, C., Butler, M., Carlson, S., Fejsa, J. and Durrheim, D. (October 2015). 'Flutracking: a review of the first 10 years growth and insights'. Paper presented at the 11th Australian Influenza Symposium, Geelong, Victoria, Australia.

Devictor, V., Whittaker, R. J. and Beltrame, C. (2010). 'Beyond scarcity: citizen science programmes as useful tools for conservation biogeography'. *Diversity and Distributions* 16 (3), pp. 354–362. DOI: 10.1111/j.1472-4642.2009.00615.x.

Dickinson, J. L., Shirk, J., Bonter, D., Bonney, R., Crain, R. L., Martin, J., Phillips, T. and Purcell, K. (2012). 'The current state of citizen science as a tool for ecological research and public engagement'. *Frontiers in Ecology and the Environment* 10 (6), pp. 291–297. DOI: 10.1890/110236.

Druschke, C. G. and Seltzer, C. E. (2012). 'Failures of engagement: lessons learned from a citizen science pilot study'. *Applied Environmental Education and Communication* 11, pp. 178–188.

Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsen, L. and Marra, P. P. (2005). 'The Neighborhood Nestwatch Program: Participant Outcomes of a Citizen-Science Ecological Research Project'. *Conservation Biology* 19 (3), pp. 589–594. DOI: 10.1111/j.1523-1739.2005.00s01.x.

Eveleigh, A., Jennett, C., Blandford, A., Brohan, P. and Cox, A. L. (2014). 'Designing for dabblers and deterring drop-outs in citizen science'. In: *Proceedings of the CHI 2014*, pp. 2985–2994. DOI: 10.1145/2556288.2557262.

Fredricks, J. A, Blumenfeld, P. C and Paris, A. H (2004). 'School Engagement: Potential of the Concept, State of the Evidence'. *Review of Educational Research* 74 (1), pp. 59–109. DOI: 10.3102/00346543074001059.

Jennett, C., Kloetzer, L., Gold, M. and Cox, A. L. (2013). 'Sociability in virtual citizen science'. In: *Proceedings of the CHI 2013 Workshop on Designing and Evaluating Sociability in Online Video Games*, pp. 29–32.

Jennett, C., Furniss, D. J., Iacovides, I., Wiseman, S., Gould, S. J. J. and Cox, A. L. (2014). 'Exploring Citizen Psych-Science and the Motivations of Errordiary Volunteers'. *Human Computation* 1 (2), pp. 199–218. DOI: 10.15346/hc.v1i2.10.
Jensen, E. (2014). 'The problems with science communication evaluation'. *JCOM* 13 (1), C04. URL: http://jcom.sissa.it/archive/13/01/JCOM_1301_2014_C04.
Jordan, R. C., Gray, S. A., Howe, D. V., Brooks, W. R. and Ehrenfeld, J. G. (2011). 'Knowledge gain and behavioral change in citizen-science programs'. *Conservation Biology: the Journal of the Society for Conservation Biology* 25 (6), pp. 1148–1154. DOI: 10.1111/j.1523-1739.2011.01745.x.
Kline, P. (1999). The Handbook of Psychological Testing. 2nd ed. London, U.K.: Routledge.
Land-Zandstra, A. M., Devilee, J. L. A., Snik, F., Buurmeijer, F. and van den Broek, J. M. (2015). 'Citizen science on a smartphone: ParticipantsâĂŹ motivations and learning'. *Public Understanding of Science* 25 (1), pp. 45–60. DOI: 10.1177/0963662515602406.
Marquet, R. L., Bartelds, A. I., Noort, S. P., Koppeschaar, C. E., Paget, J., Schellevis, F. G. and Zee, J. (2006). 'Internet-based monitoring of influenza-like illness (ILI) in the general population of the Netherlands during the 2003–2004 influenza season'. *BMC Public Health* 6, p. 242. DOI: 10.1186/1471-2458-6-242.
National Research Council (2009). Learning Science in Informal Environments: People, Places, and Pursuits. Ed. by P. Bell, B. Lewenstein, A. W. Shouse and M. A. Feder. Washington, D.C., U.S.A.: National Academies Press. URL: http://www.nap.edu/catalog/12190.
Newman, G., Wiggins, A., Crall, A., Graham, E., Newman, S. and Crowston, K. (2012). 'The future of citizen science: emerging technologies and shifting paradigms'. *Frontiers in Ecology and the Environment* 10 (6), pp. 298–304. DOI: 10.1890/110294.
Nov, O., Arazy, O. and Anderson, D. (2011a). 'Dusting for Science: Motivation and Participation of Digital Citizen Science Volunteers'. In: *Proceedings of the 2011 iConference*, pp. 68–74. DOI: 10.1145/1940761.1940771.
— (2011b). 'Technology-mediated citizen science participation: a motivational model'. In: *Proceedings of the Fifth international AAAI Conference on Weblogs and Social Media*. (Barcelona, Spain), pp. 249–256.
— (2014). 'ScientistsHome: what drives the quantity and quality of online citizen science participation?' *PloS One* 9 (4), e90375. DOI: 10.1371/journal.pone.0090375.
Paolotti, D., Carnahan, A., Colizza, V., Eames, K., Edmunds, J., Gomes, G., Koppeschaar, C., Rehn, M., Smallenburg, R., Turbelin, C., Van Noort, S. and Vespignani, A. (2014). 'Web-based participatory surveillance of infectious diseases: the Influenzanet participatory surveillance experience'. *Clinical Microbiology and Infection* 20 (1), pp. 17–21. DOI: 10.1111/1469-0691.12477.
Raddick, M. J., Bracey, G., Gay, P. L., Lintott, C. J., Murray, P., Schawinski, K., Szalay, A. S. and Vandenberg, J. (2010). 'Galaxy Zoo: Exploring the Motivations of Citizen Science Volunteers'. *Astronomy Education Review* 9 (1). DOI: 10.3847/AER2009036. arXiv: 0909.2925.
Raddick, M. J., Bracey, G., Gay, P. L., Lintott, C. J., Cardamone, C., Murray, P., Schawinski, K., Szalay, A. S. and Vandenberg, J. (2013). 'Galaxy Zoo: Motivations of Citizen Scientists'. arXiv: 1303.6886.

Reed, J., Raddick, M. J., Lardner, A. and Carney, K. (2013). 'An Exploratory Factor Analysis of Motivations for Participating in Zooniverse, a Collection of Virtual Citizen Science Projects'. In: *Proceedings of the 46th Hawaii International Conference on System Sciences*, pp. 610–619. DOI: 10.1109/HICSS.2013.85.

Riesch, H. and Potter, C. (2014). 'Citizen science as seen by scientists: methodological, epistemological and ethical dimensions'. *Public Understanding of Science* 23 (1), pp. 107–120. DOI: 10.1177/0963662513497324.

Riesch, H., Potter, C. and Davies, L. (2013). 'Combining citizen science and public engagement: the Open AirLaboratories Programme'. *JCOM* 12 (3), A03. URL: http://jcom.sissa.it/archive/12/3-4/JCOM1203%282013%29A03.

Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., Lewis, D. and Jacobs, D. (2012). 'Dynamic Changes in Motivation in Collaborative Citizen-science Projects'. In: *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work*. (Seattle, WA, U.S.A. 11th–15th February 2012), pp. 217–226. DOI: 10.1145/2145204.2145238.

Sauermann, H. and Franzoni, C. (2015). 'Crowd science user contribution patterns and their implications'. *Proceedings of the National Academy of Sciences* 112 (3), pp. 679–684. DOI: 10.1073/pnas.1408907112.

Silvertown, J. (2009). 'A new dawn for citizen science'. *Trends in Ecology & Evolution* 24 (9), pp. 467–471. DOI: 10.1016/j.tree.2009.03.017.

Socientize (2013). *Citizen Science for Europe: towards a better society of empowered citizens and enhanced research. Green paper on citizen science*. URL: www.socientize.eu.

Theobald, E. J., Ettinger, A. K., Burgess, H. K., DeBey, L. B., Schmidt, N. R., Froehlich, H. E., Wagner, C., HilleRisLambers, J., Tewksbury, J., Harsch, M. A. and Parrish, J. K. (2015). 'Global change and local solutions: tapping the unrealized potential of citizen science for biodiversity research'. *Biological Conservation* 181, pp. 236–244. DOI: 10.1016/j.biocon.2014.10.021.

Tinati, R., Van Kleek, M., Simperl, E., Luczak-Rösch, M., Simpson, R. and Shadbolt, N. (2015). 'Designing for Citizen Data Analysis: a Cross-Sectional Case Study of a Multi-Domain Citizen Science Platform'. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. (Seoul, Korea, 18th–23rd April 2015), pp. 4069–4078. DOI: 10.1145/2702123.2702420.

Trumbull, D. J., Bonney, R., Bascom, D. and Cabral, A. (2000). 'Thinking scientifically during participation in a citizen-science project'. *Science Education* 84 (2), pp. 265–275. DOI: 10.1002/(SICI)1098-237X(200003)84:2<265::AID-SCE7>3.0.CO;2-5.

van Noort, S. P., Codeço, C. T., Koppeschaar, C. E., van Ranst, M., Paolotti, D. and Gomes, M. G. M. (2015). 'Ten-year performance of Influenzanet: ILI time series, risks, vaccine effects, and care-seeking behaviour'. *Epidemics* 13, pp. 28–36. DOI: 10.1016/j.epidem.2015.05.001.

Vandendijck, Y., Faes, C. and Hens, N. (2013). 'Eight years of the Great Influenza Survey to monitor influenza-like illness in Flanders'. *PloS One* 8 (5), e64156. DOI: 10.1371/journal.pone.0064156.

Wójcik, O. P., Brownstein, J. S., Chunara, R. and Johansson, M. A. (2014). 'Public health for the people: participatory infectious disease surveillance in the digital age'. *Emerging Themes in Epidemiology* 11, p. 7. DOI: 10.1186/1742-7622-11-7.

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