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Final analysis and guidelines of incentives and motivation within citizen science

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| Abstract | This deliverable updates the initial analyses conducted by the ACTION team regarding the use and effectiveness of incentives, as well as distinct motivations and motivational factors within pollution citizen science. We analysed the contributors' motivation in participating in the Citizen Science pilots of the project. We look at the contributors' expectations in their experiences and how these affect the quality of their results. Also, we explore the use of gamification to improve contributors engagement. The document then concludes with a list of guidelines derived from our studies' findings to help researchers or practitioners design future Citizen Science and crowdsourcing initiatives. |
| Keywords | Citizen science, motivation, crowdsourcing, contributors' expectations, and gamification. |

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EXECUTIVE SUMMARY

This document discusses incentives and motivation as central factors to enhance engagement and participation in Citizen Science. It extends and updates the previous D5.6. The document contains results on a new survey of motivations performed with ACTION pilots. Also, D5.7 presents a study on drivers of human behaviours inside communities of citizen scientists, with the collaboration of the Dutch Butterfly Conservation organisation. Finally, we present two studies that aim to investigate how contributors' expectations and the use of gamification affect their motivation and engagement.

In the first section, we present a study performed by ACTION partner CEFRIEL. This study used a motivational survey consisting of 20 questions and focusing on 10 distinct motivational factors, which volunteers from 6 ACTION pilots were asked to complete. Participants across projects gave the highest rating to factors including *achievement*, *benevolence*, *self-direction* and *universalism*, while *conformity*, *power* and *routine* received the lowest scores.

In the second section, partners DRIFT present the results of a motivational survey with participants in ACTION partner Dutch Butterfly Conservation's citizen science pilots, as well as interviews from project administrators. Their results suggest that participants are motivated to participate due to a range of factors, most notably supporting the goals of the project, an interest in the project's research and a desire to contribute to research more generally.

Following this, we present an experiment exploring how participants in online crowdsourced tasks respond to results which do not match their expectations, using a dice-rolling task with loaded dice designed to deliberately contradict the assumed statistical distribution of results. Findings suggest a willingness on the part of participants to perform further tasks to attempt to converge on the expected results, as well as a general dissatisfaction with results which do not match participants' or task administrators' expectations.

As a final study, we present an analysis of the effectiveness of gamified and financial incentives in the platform Qrowdsmith, designed at King's College London to facilitate volunteer and paid crowdsourcing activity. Results suggest that while financial incentives were most effective at encouraging participants to continue to contribute to tasks, such submissions were less accurate than those submitted by participants offered gamified incentives. Furthermore, participants performed on average significantly more tasks *voluntarily* than they did after being offered a furtherance incentive.

The primary outcome of the documents consists of guidelines we have developed with the expertise gained from these four studies. These guidelines are intended to help Citizen Science researchers and practitioners who aim to improve participant motivation and engagement in their future campaigns.

1 INTRODUCTION

This deliverable extends the previous D5.6 (Initial analysis and guidelines of incentives and motivation within citizen science), which outlined research into the motivations associated with volunteer participation in citizen science in the domain of pollution and the effectiveness of financial incentives in motivating participation. D5.6 presented a survey aimed at identifying factors that motivated participation within a photometer network for monitoring light pollution and compared these with participation in crowdsourcing more broadly. Also, we studied motivations for commencing and ceasing participation in a butterfly counting citizen science project which monitors the impacts of chemical pollution such as pesticides on different species. We explored the impact that financial incentives have on a light pollution monitoring project, to understand how continued participation is impacted by these payments.

The first part of the deliverable D5.7 focuses on motivation in Citizen Science. First we present a study of motivations among volunteers in citizen science projects. It is a follow up to the experiment conducted with the TESS network during the first period of the ACTION project, described in deliverable 5.4. This further investigation includes all the second cohort pilots from the ACTION accelerator. The chapter includes the individual results and a comparison of differences and commonalities with the global results. Finally, it also includes a comparison with the first study.

Following this, in section 2 we present an analysis of motivations for participating in a conservation citizen science project: Dutch Butterfly Conservation. Participation in this project is particularly interesting because of the long-term engagement of the volunteers, up to 30 years. We analysed motivations for joining DBC as part of a larger study about community engagement in this citizen science project.

For the remainder of the deliverable, we investigate how incentives can increase motivation and participation in Citizen Science. Generally, Citizen Science relies on volunteer activity and studies suggest that intrinsic motivations (e.g. interests and altruism) are the primary factor which drive participation from contributors (see for example: Nov et al., 2014). In practice, however, the factors which make a task attractive to participants are poorly understood and this is particularly problematic in the case of dull, prolonged or repetitive tasks, which may struggle to find volunteers. In 5.6, we discussed some of the most commonly occurring incentives within the literature, i.e., financial Incentives, physical incentives/rewards, gamification, and competitions. In this document, we focus on financial incentives and gamification and presented two studies on that.

For this study, we held our experiments on the Prolific crowdsourcing platform, which serves as a participant recruitment platform for microtask crowdsourcing. In contrast with citizen science platforms, Prolific relies on *paid* participation but use of this platform allowed us to have more control on the participants of the experiments. Specifically, using Prolific offered three main benefits: (i) *Independency of contributors* - the experiment needs contributors not to influence each other. This could be guaranteed by Prolific, but could not be guaranteed for pilots where participants often know each other and may be part of the same communities; (ii) *alignment of initial motivation* - in our experiment we assumed all the participants are equally motivated since monetary payment is the primary motivating factor in crowdsourcing, whereas in the ACTION pilots individual motivations and levels of engagement were likely to vary from among various intrinsic motivations e.g. Sense of belonging, wish of learning, curiosity, or altruism; and (iii) *scale*, recruiting

large numbers of contributors from Prolific is straightforward as the platform is built for that purpose. Conversely, trying to recruit a comparable number of contributors from ACTION pilots would have been much more complex and would have taken significantly more time. This in turn would risk not being able to reach the fixed target of individuals required.

However, we are confident that the results obtained in our experiment can easily be generalised to Citizen Science as well. Indeed, the main difference between Citizen Science and crowdsourcing participants is the initial motivation, which tends to be stronger in the first case since it is on a volunteer basis. Thus, it is reasonable to think that the findings of crowdsourcing studies are potentially stronger because they were obtained in a more complicated context, with contributors only motivated by monetary payments which are considered a less effective motivational method in literature studies.

Again relying on crowdsourcing contributions, we focus on contributors' expectations in crowdsourcing and Citizen Science initiatives. Indeed, since the beginning of the participation in a study, contributors formulate expectations on various aspects of their experience, e.g., how difficult the task will be; what they will learn by carrying it out; or, what the final results will look like. In our study, we show how different can be expectations formulated by different individuals. Also, we discuss how unmet expectations can affect contributors' experiences, thus consequently, the action they will take. To do that, we ran an experiment in which a strong expectation we created ad hoc was not matched by the experiment results. Thus we analysed the contributors' behaviour and task results. Also after the tasks, contributors had to participate in a survey by which we could investigate the reasons for contributors' choices. To summarise, expectation plays a significant role in the contributor motivation, and responses might vary consistently among individuals in relation to satisfaction and dissatisfaction of expectations.

Finally, we present an experiment on furtherance incentives using financial and gamified incentives. This study was performed in Qrowdsmith, the inhouse gamified platform presented in D5.4. In our previous work, described in D 5.6, we analysed how financial incentives contribute to long-term engagement and worker retention in paid crowdsourcing platforms. While these payments may not appear to align with the intrinsic motivations that commonly drive citizen science participation, they have nevertheless been used to varying extents in projects of varying sizes (see D 5.6 and for example: Simperl et al, 2018). However, where our previous work focused on encouraging workers to *return* to tasks, in this deliverable we focus on the question of how to drive increased engagement and to delay the point at which workers *leave* a task. Both of these issues are crucial to maximising engagement in citizen science, particularly given the significant disparity between the majority of workers and the small, highly active minority who perform the majority of the work (Sauermann and Franzoni, 2015).

With the experience and the findings we gained in the four studies presented in the deliverable, we generate some guidelines which are reported at the end of this document. These are meant to be used as general suggestions for practitioners or researchers who need to run citizen Science, or more in general crowdsourcing, campaigns for which the aspects like contributors' motivations or engagement that might result are decisive for the success of the initiative. More in general, our goal is to inform and raise awareness in requesters about how aspects often underestimated, such

as user expectations or engagement, play a central role in the user experience. And to point out how these might be the main responsible for the failure of campaigns when neglected.

2 STUDY OF MOTIVATION FOR CITIZEN SCIENTISTS

Studying motivation and investigating the factors influencing people's participation in citizen science projects is an essential aspect in the analysis of citizen science communities. Understanding the reasons that foster people to engage can support the successful design and implementation of effective participant involvement tasks, as well as pave the way for long-term engagement (Richter et al, 2018).

In this chapter we describe the study conducted to investigate drivers of human behaviours inside communities of citizen scientists. The study reported in this chapter is the follow up of the study described in chapter 3 of Deliverable 5.6 (Reeves et al., 2021). In Deliverable 5.6 we reported the methodology and the results of the experiment conducted on the TESS Network community, a citizen science campaign fighting light pollution that participated in the first ACTION acceleration program. In this chapter we describe how we conducted the same study about motivation on the six citizen scientist pilots who took part in the second ACTION acceleration program.

2.1 Methodology

The detailed description of the methodology used to study the motivation of citizen scientists is explained in chapter 3 of Deliverable 5.6.

As a quick recap, the study consists in investigating the drivers of human behaviours inside communities of citizen scientists through surveys using the CONEY toolkit (explained in deliverable 4.1). The survey is composed of questions relying on existing questionnaires (Richter et al, 2018) used to evaluate the level of motivations of participants to Citizen Science projects.

The core of the questionnaire is composed of 20 closed questions (5-point Likert scale) investigating 10 variables, related to altruism and intrinsic motivation (*self-direction, stimulation, hedonism, achievement, power, conformity, benevolence, universalism, routine and belongingness*) that may be correlated to and may influence the main goal of the investigation, which is the global motivation of citizen scientists.

Table M1 shows the list of the core questions with the corresponding variable they describe.

| Variable | Question |
|----------------------|--|
| Achievement-1 | Does the participation in <i>[the CS campaign]</i> represent an opportunity for you to improve your performance? |
| Achievement-2 | Does your participation in <i>[the CS campaign]</i> represent an opportunity to do something meaningful? |

| | |
|-------------------------|---|
| Belongingness-1 | Is your participation in <i>[the CS campaign]</i> influenced by the desire to meet people with similar interests? |
| Belongingness-2 | By joining <i>[the CS campaign]</i> , do you feel part of something worthwhile? |
| Benevolence-1 | How much do you see your participation in <i>[the CS campaign]</i> as a good thing to do? |
| Benevolence-2 | Do you participate in <i>[the CS campaign]</i> to contribute and help scientific research? |
| Conformity-1 | Do you know other people participating in <i>[the CS campaign]</i> ? |
| Conformity-2 | To what degree were you obliged to participate in <i>[the CS campaign]</i> ? |
| Hedonism-1 | Does your participation in <i>[the CS campaign]</i> make you feel good about yourself? |
| Hedonism-2 | How passionate are you about the <i>[CS campaign]</i> ? |
| Power-1 | Do you believe your participation allows you to gain recognition and status? |
| Power-2 | Do you expect something in return from your participation in <i>[the CS campaign]</i> ? |
| Routine-1 | Have you ever done <i>[these CS tasks]</i> before joining this community? |
| Routine-2 | How regularly do you participate in citizen science projects related to this task? |
| Self-direction-1 | How much do you expect to learn from your participation in <i>[the CS campaign]</i> ? |
| Self-direction-2 | Are you interested in <i>[CS campaign or topics of the campaign]</i> ? |
| Stimulation-1 | Did you join the <i>[CS campaign]</i> to have the possibility to do something new? |
| Stimulation-2 | Do you think your participation in <i>[the CS campaign]</i> is an opportunity to challenge yourself? |

| | |
|-----------------------|--|
| Universalism-1 | Do you participate in <i>[the CS campaign]</i> for the possibility to make data about <i>[CS topics]</i> more accessible? |
| Universalism-2 | How much do you see your participation as a possibility to raise public awareness to the topic of <i>[the CS campaign]</i> ? |

Table M1: Variables and corresponding questions

The generic formulation of these questions was customised to better fit the context of each community. During interactive sessions with the pilots, we co-create the final survey for volunteers. In some cases, we removed some questions that did not fit the context of the community, or we made the questions more specific for the use case. In any case we ensured that at least one question for each variable was inserted in the final questionnaire.

In addition to these questions the survey includes one closed question to ask the level of global motivation on a scale of 5 values and an open question asking why participants decided to join the citizen science community to let them freely express their motivations for participating.

The survey also contains some questions for profiling the respondents in terms of demographic and level of engagement in the community and, for those pilots for which it is applicable, we added an extra question to verify the impact of COVID-19 on the pilots' activities. These questions were agreed with the pilots during the co-creation sessions.

In the next chapter we describe the customization we did for each pilot, and we report the results collected.

2.2 Case studies and results

This section describes the six use cases analysed, by detailing the context and the customization of the survey to the specific scenario and by reporting the analysis done on the data collected.

2.2.1 Description of campaigns and respondents

The experiment was conducted on the six projects participating to the second ACTION acceleration program¹: Open Soil Atlas, Restart Data Workbench, Water Sentinels, Wow Nature, Walk Up Aniene and Mapping Mobility. The pilots differ in terms of type pollution fought, task performed and type of participants' involvement. An aggregated overview of all the information related the pilots is available in the infographic² on ACTION website and in the Deliverable "D4.9 Live dashboard and media publishing portal 2".

Open Soil Atlas

¹ <https://actionproject.eu/citizen-science-pilots/>

² <https://actionproject.eu/pilotsfactsheet/>

Open Soil Atlas is a citizen science community of around 170 people focused on fighting soil pollution, based in Berlin (Germany). The pilot created an open-source co-learning centre for the local community of Berlin, with the aim of educating the public and raising awareness about soil quality and fertility and the correlation between healthy soil and healthy communities.

A series of free workshops were organised, where citizens were taught how to make observations, test the soil, interpret results, and draw conclusions. In addition, online material was made available through a website presenting guidelines in a textual and infographic form.

The task of volunteers consists in an on-field data collection for measuring what's below the surface, to collect data about the carbon storage potential of the soil and the availability of space for urban gardening. Citizens are asked to classify the soil in terms of land use, colour, texture, pH level and profile. Combined with GPS locations, data about soil quality and soil fertility were then uploaded in a digital entry form (an Epicollect application³), which, in the long term, will generate a high-resolution soil quality map.

The survey was translated in 5 languages (Spanish, French, Italian, German and English) since the community is composed of people from different European countries. During the co-creation session we decided to add a question to collect the background knowledge of volunteers in the soil analysis field and some questions about diversity and inclusion. We also removed some questions that do not fit this use case: Routine-2, Hedonism-2, Power-1, Belongingness-2 and Conformity-2.

22 participants started the survey and 14 of them filled it entirely (63% response rate) from mid-May to the beginning of August. More than half of respondents are women, younger than 30 years old (cf. Figure M1 and Figure M2), single and without children. They come from Germany (the majority), Italy, France and Denmark.

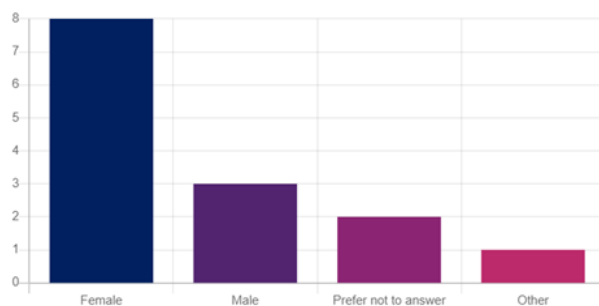


Figure M1: To which gender identity do you most identify?

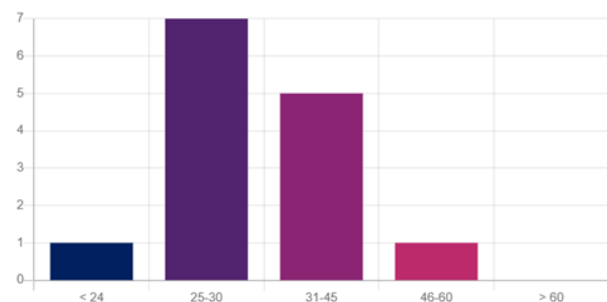


Figure M2: How old are you?

Most of them have a bachelor's or master's degree. There are both students and employed workers (cf. Figure M3 and Figure M4).

³ <https://five.epicollect.net/project/open-soil-atlas-action-2021>

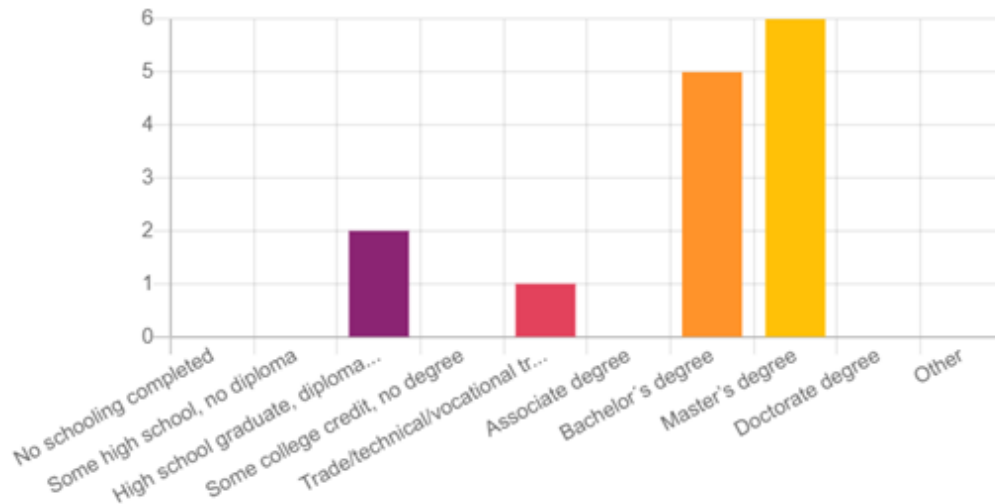


Figure M3: What is the highest degree or level of school you have completed?

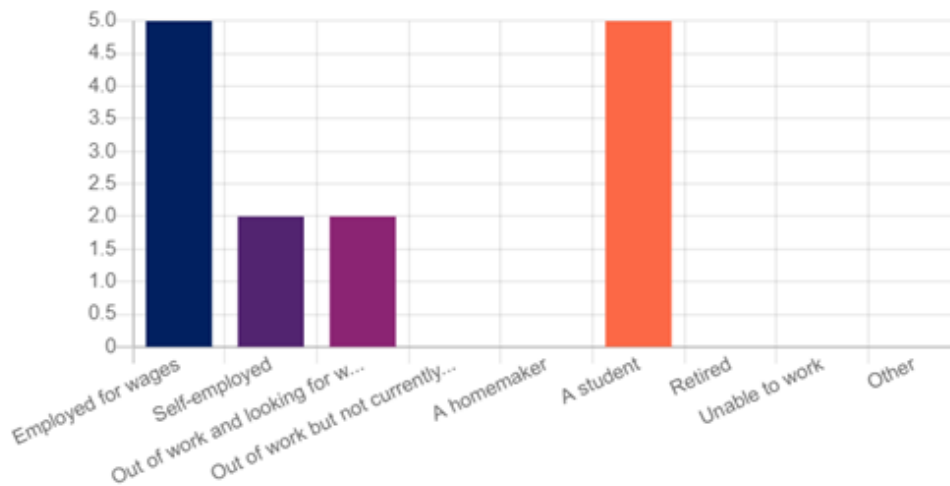


Figure M4: What is your employment status?

Regarding their background knowledge in the field of soil quality and fertility, most of them considers themselves “Soil beginner” (cf. Figure M5). Two participants are completely new to this field while four volunteers have some background experience.

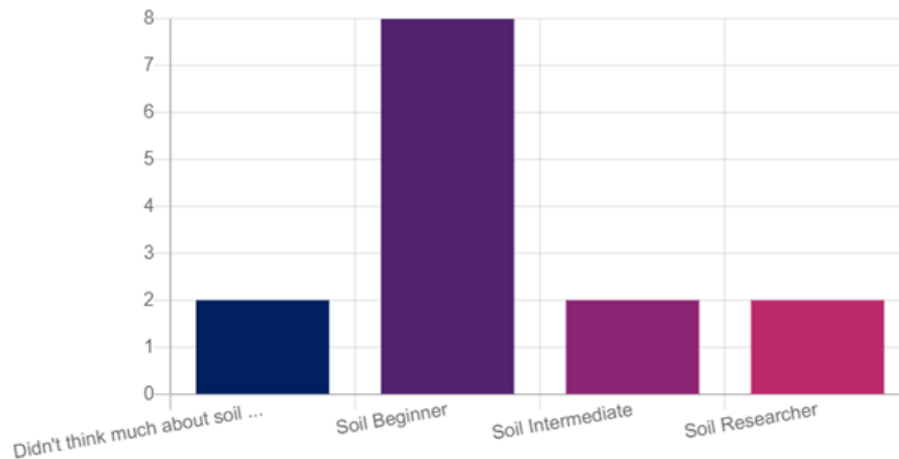


Figure M5: Which of the following categories identifies you the most?

Respondents perceived the pandemic situation in different ways: some participants said to be limited in the project's activities while others were not limited by the COVID-19 restrictions. Others even used the project's activities as a good excuse to leave home, as shown in Figure M6.

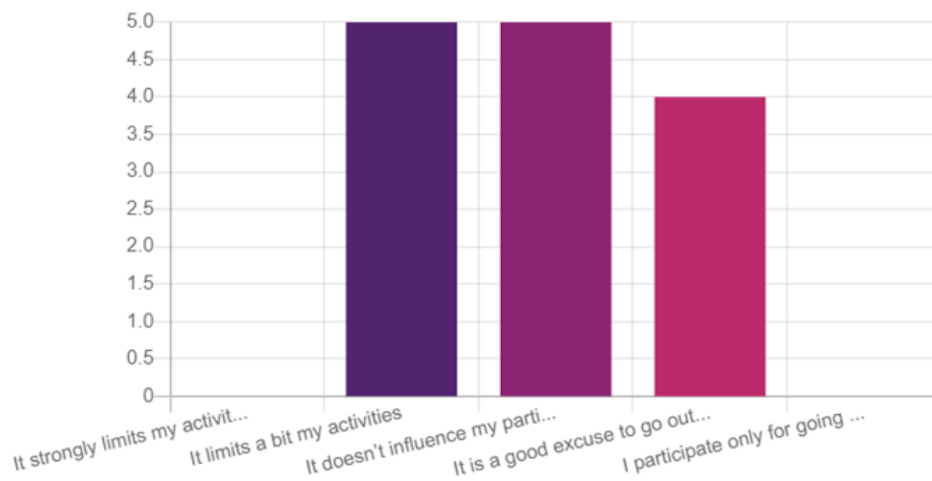


Figure M6: How does the pandemic situation influence your participation in the project?

The average value of global motivation is 3.93 on a scale of 5 (with variance 0.69). This data has been collected by asking directly to compilers their perceived level of motivation to participate in this initiative. Figure M7 shows the distribution of the values of global motivation collected. The word cloud of Figure M8 has been created starting from the open question about the main motivations. The motivations are linked to the desire of actively participating in mapping the soil quality and to do networking/sharing of data collected to make them more accessible. Participants also want to help science and learn new skills.



Figure M7: How much are you motivated in participating in the Open Soil Atlas project?



Figure M8: In your own words, what is the main motivation why you decided to participate in the project?

Volunteers were also asked to describe what excites them about the Open Soil Atlas mission and vision. Some of them appreciated the possibility to increase soil awareness and education and to raise the responsibility to their living environment by creating a more caring way of living within the city. Other participants enjoyed the open source and citizen-driven approach that allowed everyone who is interested to be part of the community, including people who are no soil experts. They consider this project a starting point for change by tackling climate change from the ground up. The appreciated goal of doing something productive for the community at large using a scientific approach.

Regarding the inclusion and diversity topics, volunteers believe that the main obstacles that may exclude someone from the project are language (non-English/German speaking folks may be precluded) and mobility barriers (people with mobility problems, e.g. wheelchair). Other people that could be excluded are those who are not familiar with technology for which it could be hard to discover the project without social media or internet. Cultural minorities and people who are very busy with their time could have problems participating in the project.

To overcome these problems, volunteers suggested preparing materials translated in multiple languages and to find locations with disability access for the events. To improve the advertising of the project, they suggested increasing word of mouth, to organise real life meetups and communities and to start networking with cultural associations and social workers.

Regarding the technical accessibility of the workshop, volunteers assessed it as quite good (average 3,73 on a scale 1-5), as shown in Figure M9.

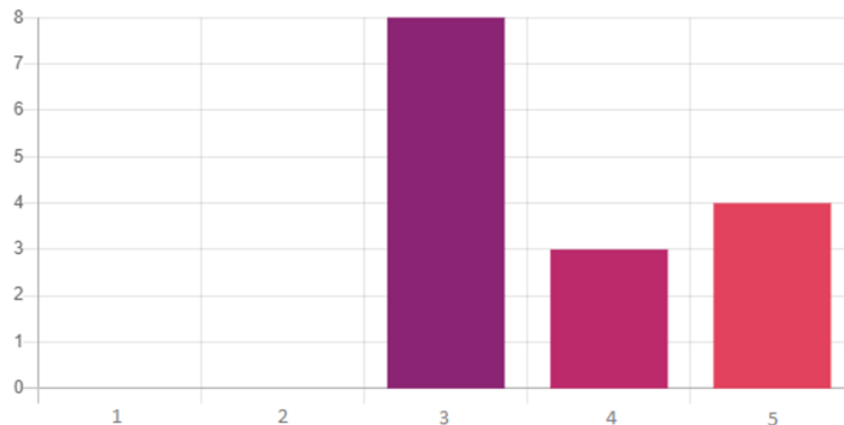


Figure M9: How would you assess the technical accessibility of the workshop?

Regarding the possibility of sharing the equipment with other participants (sharing economy), all the participants except one are in favour of this initiative.

Restart Data Workbench

Restart Data Workbench is a citizen science community of around 300 active participants focused on fighting soil pollution and waste reduction/management that performs its activities exclusively online. The Restart Project manages a global network of voluntary groups (mostly in Europe) who help their local communities repair broken products, preventing pollution in production and disposal.

Restart Data Workbench addresses the global dimensions of pollution and consumerism, the impacts of our take-make-throw economy and the benefits in giving longer life to electronic devices. Many imported goods have really short lifespans, which the Restart Data Workbench repair community tries to extend during the community repair events. Repairing electronics' devices can contribute to reducing pollution since around 80% of a small electronic devices' carbon footprint is emitted before it even reaches European shores.

The Restart Data Workbench team periodically organised some online community events where community members are invited. In addition to that, the wider public is engaged by creating very short online microtasks (less than 5 minutes) to analyse data about attempted repairs, investigating the environmental impacts of the products repaired and using these results to influence policy discussions.

We implemented the survey using Coney in six different languages (English, Spanish, Dutch, French, German and Italian) since the volunteers are very heterogeneous in terms of spoken languages. The survey was advertised and shared during the community events. In addition, the link of the survey was added to the home page of the project's website (<https://restarters.net/workbench>) to try to collect answers also from the website's visitors.

10 volunteers started the survey and 9 of them filled it entirely (90% response rate) from the beginning of June to the beginning of August. Volunteers are very heterogeneous in terms of age (cf. Figure M11) and most of them are male (cf. Figure M10).

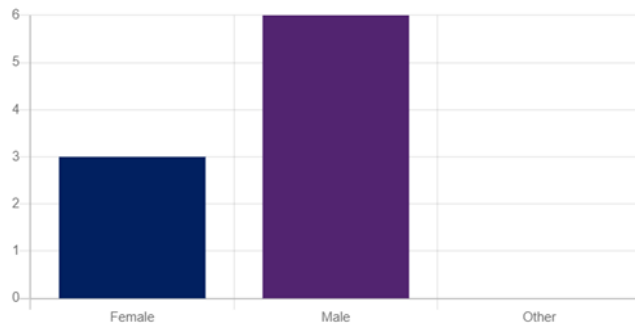


Figure M10: With which gender identity do you most identify?

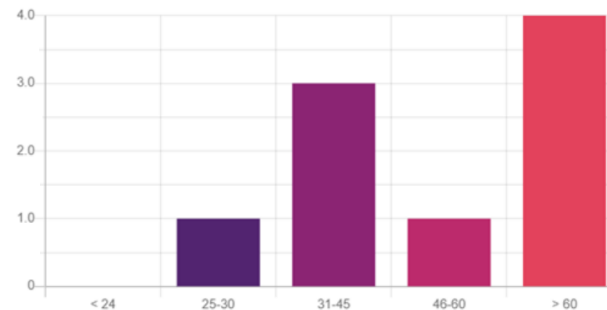


Figure M11: How old are you?

The volunteers have expertise in different field, there are repairers, community organisers, right to repair advocates, data analyst and environmental campaigners (cf. Figure M12). 7 out of 9 participants volunteered with a community repair group (cf. Figure M13) and in particular their groups belong to the Repair Café Foundation (3) and the Restarters Community (3).



Figure M12: Which of the following options best describe(s) you? (choose one or more)

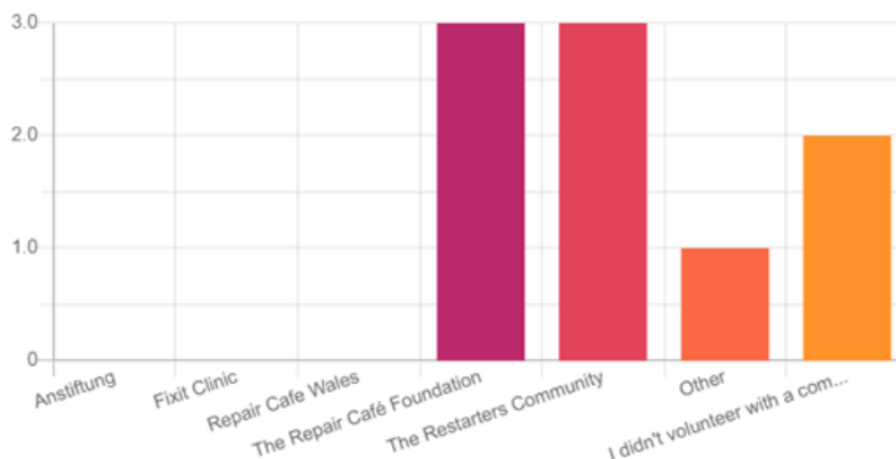


Figure M13: If you volunteer with a community repair group, which network does your group belong to?

Volunteers are very motivated to participate to the project and they rated their motivation 4.33 on a scale of 5 (cf. Figure M14). Volunteers participated because they wanted to create data about consumption of electronic devices to make all humanity aware of the problem of global e-Waste. They believe that good quality data can help people make informed choices when buying electronics and they hope that the information generated will be used in a meaningful way to do something useful for the Earth. They hope the project will help drive the discussion about the environmental impact of an electronic device from production to end of life and about the impacts of repair and right to repair (cf. Figure M15).



Figure M14: How motivated are you to participate in this project?



Figure M15: In your own words, what is the main reason you decided to participate in this project?

A shorter version of the survey was added to the online micro-tasks, in order to collect additional data in a quicker way with users that are involved in these very short tasks. This survey contains

four questions with a 5 point-Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree):

- [This micro task] has changed my view of the importance of repair
- [This micro task] has changed how I think about buying electronics
- [This micro task] has made me think more about electronic waste
- [This micro task] has increased my interest in repairing

We collected data from two micro tasks, BattCat⁴ and TabiCat⁵, as shown in Figure M16 and Figure M17. BattCat is a micro task to investigate how batteries cause devices to fail and to categorise what went wrong with each of them. TabiCat is a people-powered investigation into why tablets and e-book readers break with the goal of understanding why they fail so that they can tell policymakers how future models can be made to last longer and be easier to repair.

The participation in both micro tasks had the effect of increasing the awareness of volunteers in electronic waste. The 64% of participants in TabiCat and the 43% in BattCat declared that the project made them think about electronic waste. Also, their interest in repairing activities improved after participation in micro tasks (57% TabiCat and 36% BattCat) as well as their view of the importance of repairing electronic devices (50% TabiCat and 35% BattCat).

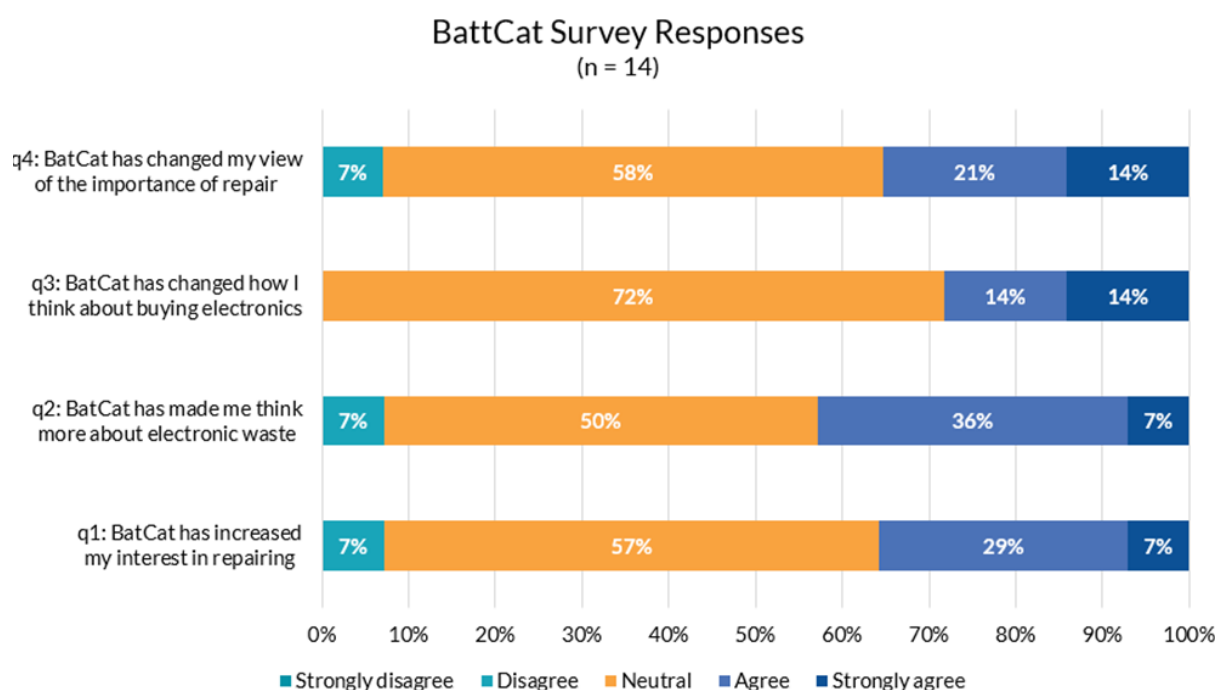


Figure M16: BattCat survey results

⁴ <https://restarters.net/battcat/status>

⁵ <https://restarters.net/tabicat/status>

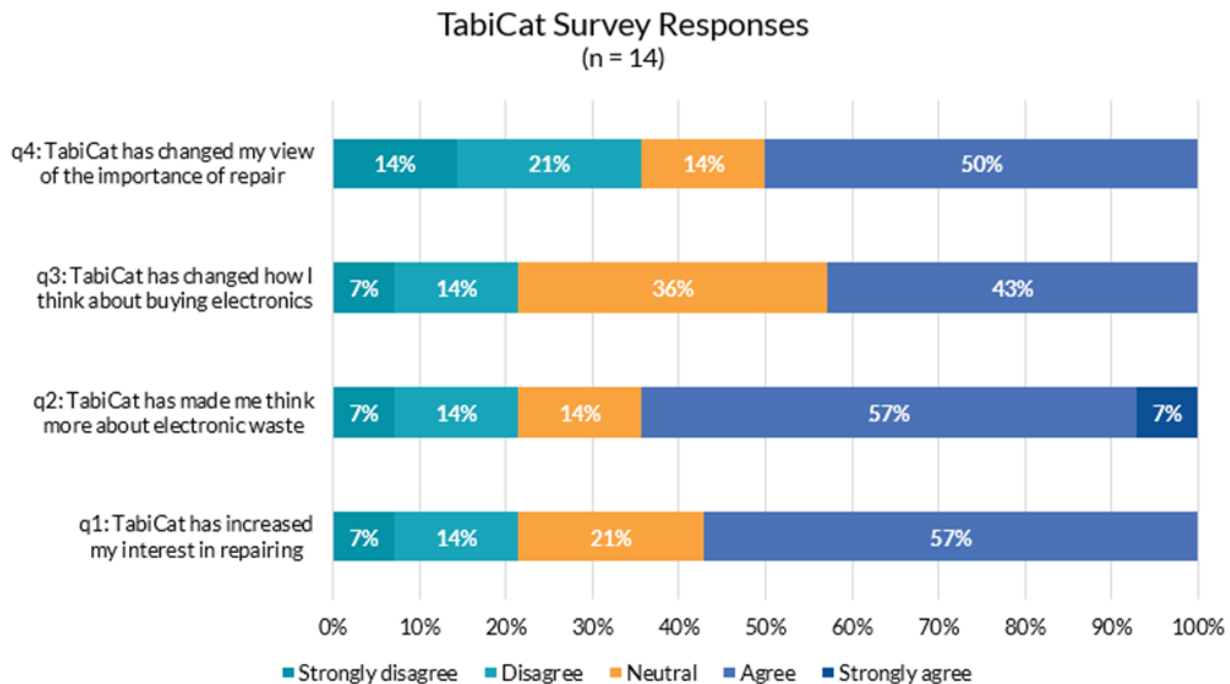


Figure M17: TabiCat survey results

Water Sentinels

Water Sentinels is a community project that empowers people from coastal communities of Portugal to play a role as citizen scientists for water quality. The aim of the project is the conservation and restoration of seagrass meadows in the Sado Estuary area (Portugal).

The pilot engages 4 people from the fishing community to detect pollution events (historical and current) that may have been failing to be detected with the current water monitoring networks. After a dedicated training, the volunteers participated in the data water sampling design and collection that took place in the Sado estuary. The data collected were made available to the public through the OceanAlive website and the COASTNET geoportal.

Since all the volunteers came from Portugal, we implemented the survey only in Portuguese. The survey was not administered using Coney, but with a paper version implemented with Google Forms, due to lack of technological skills of the participants involved.

The survey was filled by 4 participants (100% completion rate) in the period from end-June to mid-July. All the participants are women older than 45 years old with a basic education level (see Figure 18). Two volunteers live on the Setúbal bank and the other two on the Tróia bank, as shown in Figure 19.

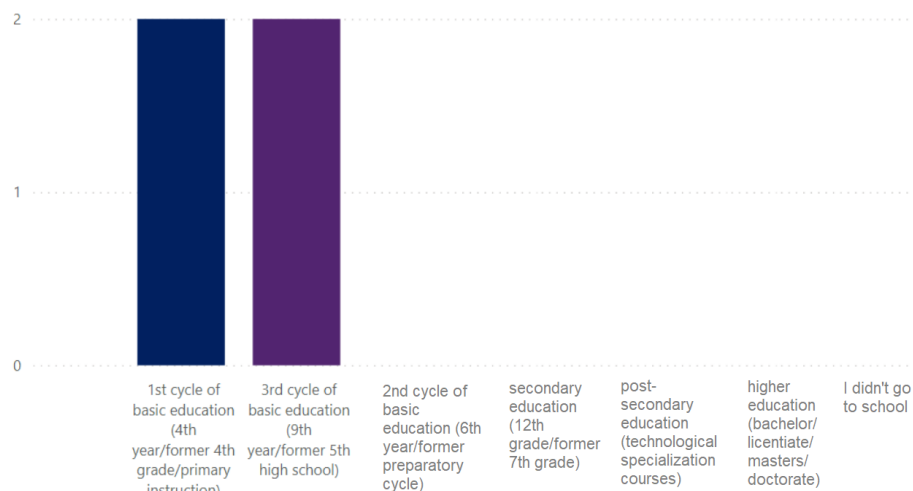


Figure M18: Which was the higher grade of school you completed?



Figure M19: In which of the sides of the estuary do you live?

Volunteers carried out all the activities of the project in which they were interested in, and they considered their global motivation in participating in the project very high (rate 5 on a scale of 5), as shown in Figure M20. They participated to assess the quality of river water and to identify the existing anomalies in it to improve the environment and to solve the mystery of many deaths that have happened in recent years (words “Mistério”=“mystery”, “Saber”=“to know” and “Água”=“water” in the word cloud of Figure M21). They would like to solve the anomalies for a better quality of life for both living beings and the planet (words “anomalies”= “anomalies”, “identificar”=“identify”, “melhorar”=“enhance”, “vida”=“life”).

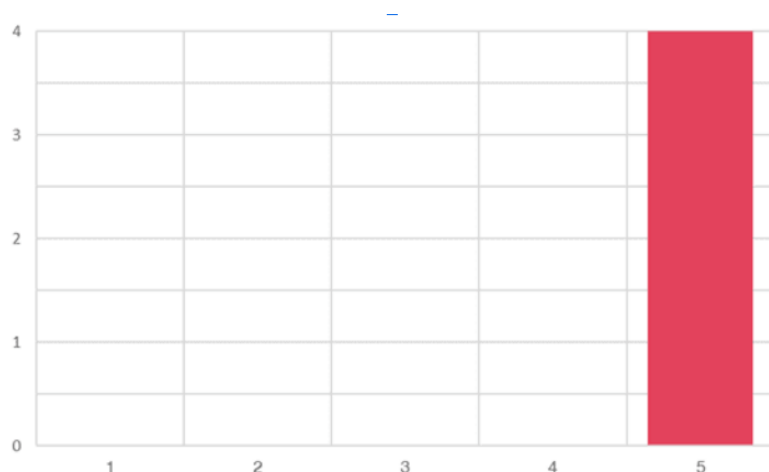


Figure M20: How much are you motivated in participating in the Water Sentinels project?

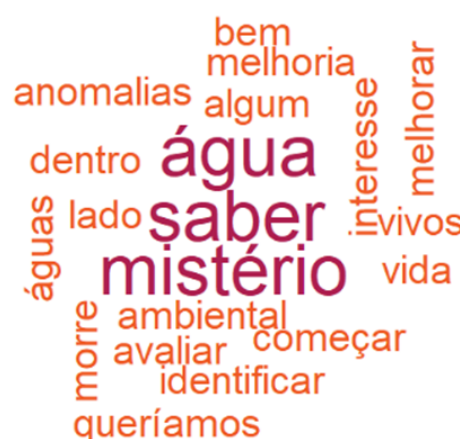


Figure M21: In your own words, what is the main motivation why you decided to participate in the Water Sentinels project? The most voted replies were: water, to know, mystery

Wow Nature

Wow Nature is a citizen science community of around 20 active participants focused on fighting air pollution, based in Italy in the region of the Po Valley. The Po Valley in Northern Italy has one of the worst air qualities in Europe, with many of its cities regularly surpassing the threshold levels for PM concentrations considered safe for human health. Luckily, trees can play a role in tackling this problem: studies all over the world are demonstrating the ability of trees in capturing PM, but evidence is needed at the local level.

The project aims to measure air pollution with innovative sensors (the Wiseair's air quality sensors) within and outside urban forests to assess their efficacy as a mitigation measure for air pollution, facilitate their funding and educate and engage with citizens.

Citizens were involved throughout the multiple phases of the project, from data collection to co-developing solutions and policies proposals. The project brings together citizens belonging to different groups and entities, such as public administrations, NGOs, associations, and businesses. Citizens provided valuable support in the following phases: identification of the most suitable location for the sensors, placement of the sensors, monitoring and warning (in case of damages to the sensors), monthly download of the data collected and dissemination of the results of the experiments.

The survey was implemented only in Italian since the participants were Italian people living in Northern Italy. During the co-creation sessions we decided to add a further question (shown in Table M2) to better investigate the *benevolence* factor.

| Variable | Question |
|----------------------|--|
| Benevolence-3 | Did you decide to participate in the project because you believe that the results of the project could help in the enhancement of the forests? |

Table M2: Additional question for Wow Nature survey

All the 8 people who received the survey filled it entirely (100% completion rate) in the period from mid-July to mid-August. Respondents are quite balanced in terms of gender (3 females and 5 males) and 6 out of 8 are younger than 45 years old (cf. Figure M22 and Figure M23).

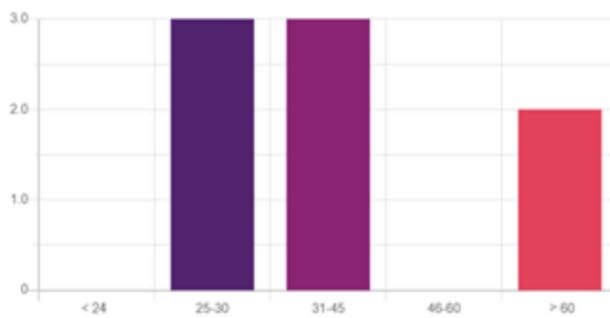


Figure M22: How old are you?

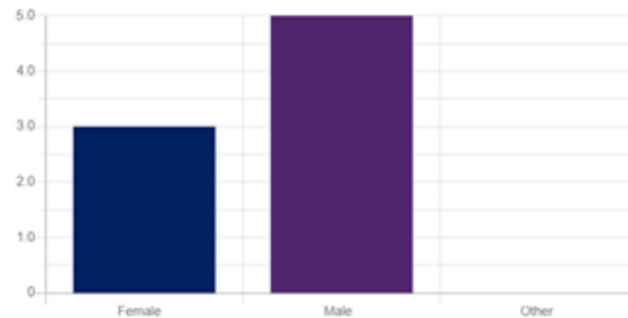


Figure M23: What's your gender?

Most of the participants are graduated (cf. Figure M24) and they are member of environmental associations, ONG, associations with training purposes and staff of a public institution (cf. Figure M25).

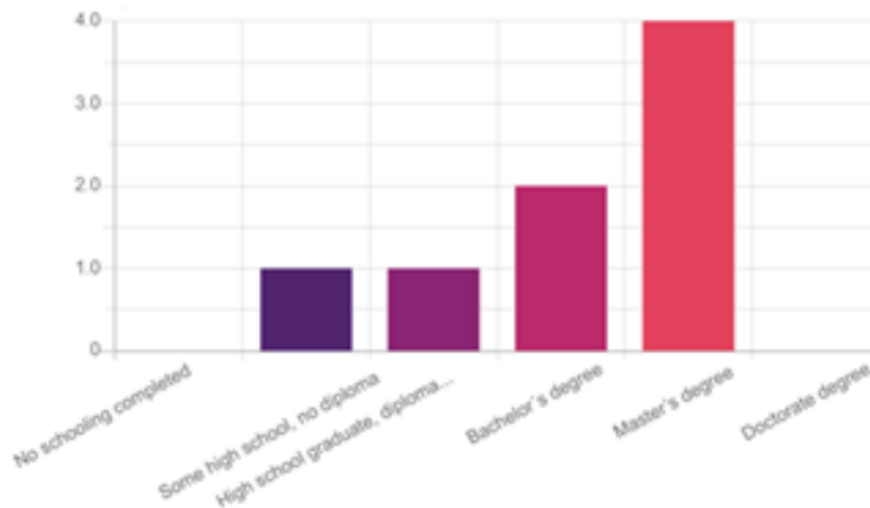


Figure M24: What is the highest degree or level of school you have completed

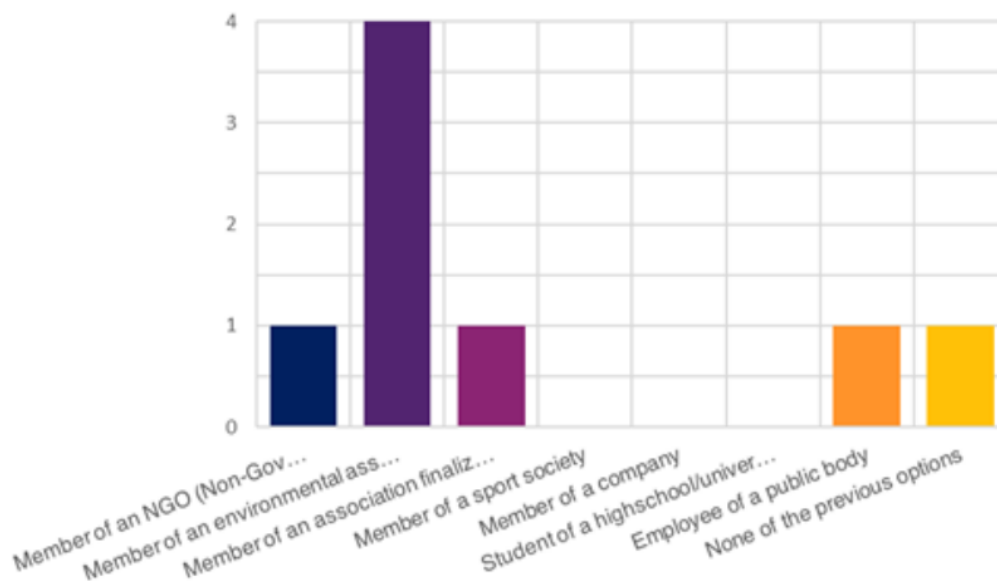


Figure M25: In which category do you mostly identify?

Regarding the engagement in the project's activities half of the volunteers participated in the design of the experiment (for example for deciding where to install the sensors), as shown in Figure M26, and 6 out of 8 participants downloaded data from sensors at least once (see Figure M27).



Figure M26: Did you participate in the design of the experiment (for example deciding where to install sensors)?

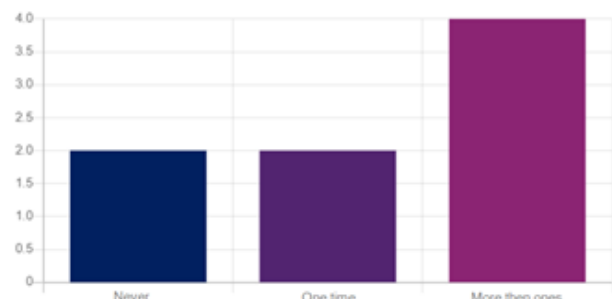


Figure M27: How many times have you downloaded data from the sensors?

All the volunteers will help disseminate the results of this experiment in the future and consider the effort required in the activities consistent with expectations (see Figure M28 and Figure M29).



Figure M28: Will you help in the dissemination of the results?

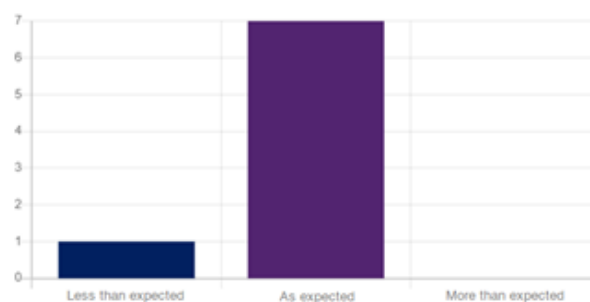


Figure M29: How was the effort required?

The pandemic situation influenced a bit the participation in the projects' activities: 3 out of 8 participants stated that the restrictions due to COVID-19 partially limited their activities in the project, as shown in Figure M30.

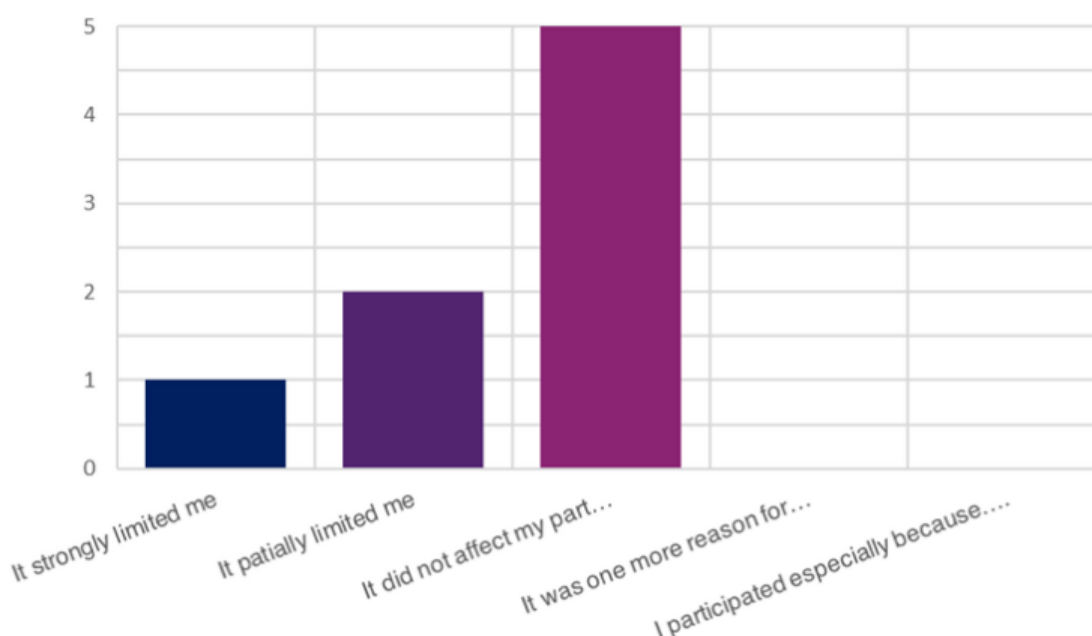


Figure M30: How does the pandemic situation influence your participation in the project?

The average value of global motivation is 3.75 on a scale of 5. Figure M31 shows that 5 out of 8 participants were very excited while only 2 were not much motivated. Volunteers participate in scientific research about the usefulness of forests to fight air pollution (words “ricerca”=“research”, “contribuire”=“contribute”, “foreste”=“forests” in the word cloud of Figure M32). They also want to take part in a project that contributes to the enhancement of the forests and that could bring positive impacts on the places where they were born (words “positivi”=“positive”, “impatti”=“impacts”, “benefici”=“benefits”).



Figure M31: How much are you motivated in participating in the Wow Nature project?



Figure M32: In your own words, what is the main motivation why you decided to participate in the Wow Nature project? The most voted replies were: research, to contribute, forest, woods

Walk Up Aniene

Walk Up Aniene is a citizen science community of around 100 people focused on fighting water and soil pollution and on monitoring biodiversity. It implements its actions in the Aniene Valley Nature Reserve, a natural area resisting urbanisation and anthropic pressure in the North East periphery of Rome (Italy).

The pilot aims to analyse the environmental quality of the river riparian area while enhancing participation at local level. About 25 people were engaged in individual observation and data gathering through mobile technologies. With the help of citizens, the goal is to map environmental criticalities, restoration needs and valuable areas to be protected and to support responsible institutions to plan environmental restoration measures.

The information is collected through a questionnaire developed by the Walk Up Aniene Team with Epicollect⁶, a digital tool which simplifies the data collection, the geo-referencing and the picture and sound gathering.

Since the community is composed of Italian people, we decided to implement the survey only in Italian. During the co-creation sessions we decided to add a further question (shown in Table M3) to better investigate the *achievement* factor and to split the self-direction-2 question into 4 different questions to analyse in more detail the different topics of the projects. Other questions were added to investigate the possible problems experienced during the data collection process and to collect suggestions to improve the initiative in the future.

⁶ <https://five.epicollect.net/project/walk-up-aniene>

| Variable | Question |
|---------------------------|---|
| Achievement-3 | Do you feel like you are contributing to a process of change aimed at improving the ways of managing the natural reserve? |
| Self-direction-2 | Are you interested in the natural reserve for recreational reasons? |
| Self-direction-2.1 | Are you interested in the safeguard of the natural reserve? |
| Self-direction-2.2 | Are you interested in the green areas near where you live? |
| Self-direction-2.3 | Are you interested in the prevention of the degradation of the area? |

Table M3: English translation of the questions added to the Walk Up Aniene survey

16 volunteers started the survey and 13 filled it entirely (81 % completion rate) from end-May to mid-July. The majority of respondents are women and are aged between 31 and 60 (cf. Figure M33 and Figure M34).

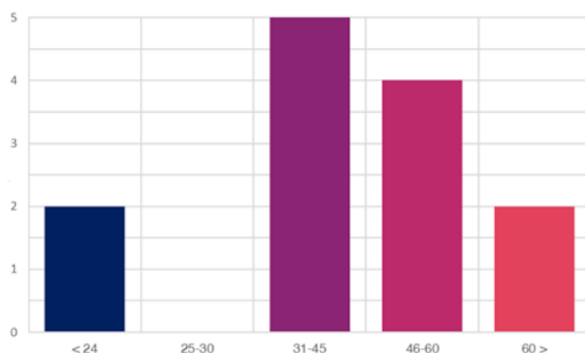


Figure M33: How old are you?

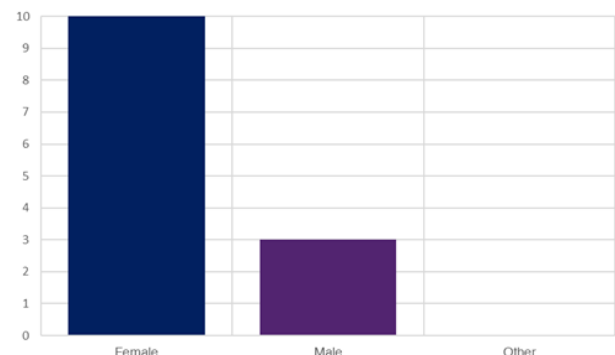


Figure M34: What's your gender?

Some volunteers are retired (3 out of 13), some are students (2 out of 13) and the rest are employees and teachers, as shown in Figure M35.

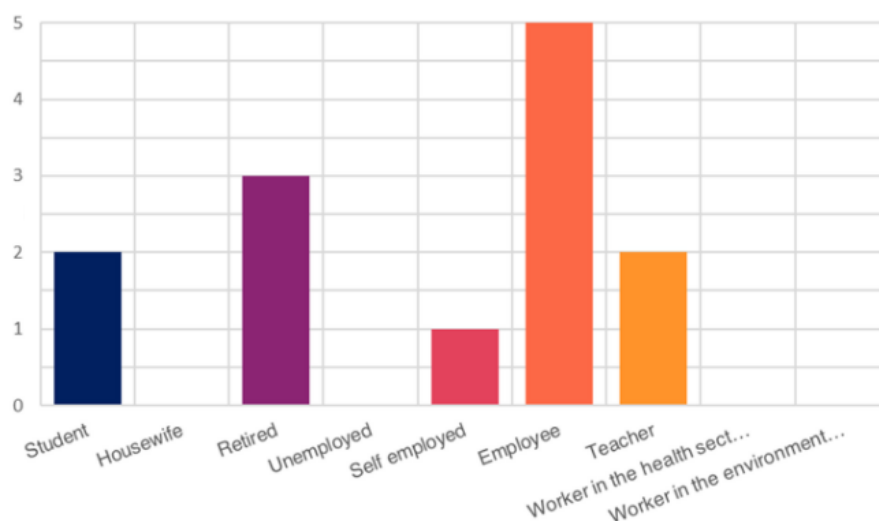


Figure M35: In which category do you most identify?

Regarding the engagement of the volunteers in the data collection task, the majority of volunteers collected data once a month (cf. Figure M36) and near the place where they live (cf. Figure M37). Only 3 respondents never collected data and only 3 out of the remaining 10 experienced some problems during this activity (for example in sending the GPS position on the field because of poor internet connection or for difficulties in reaching good observation points).

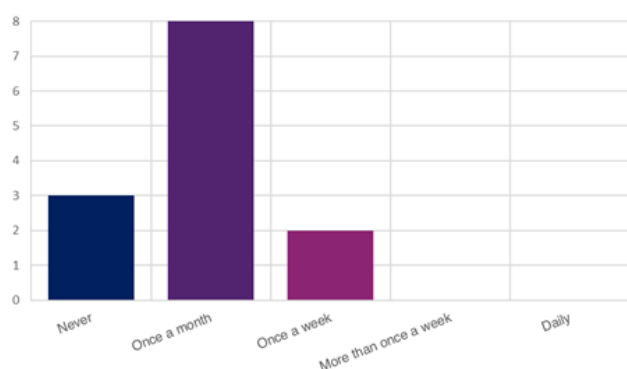


Figure M36: How often did you collect data?

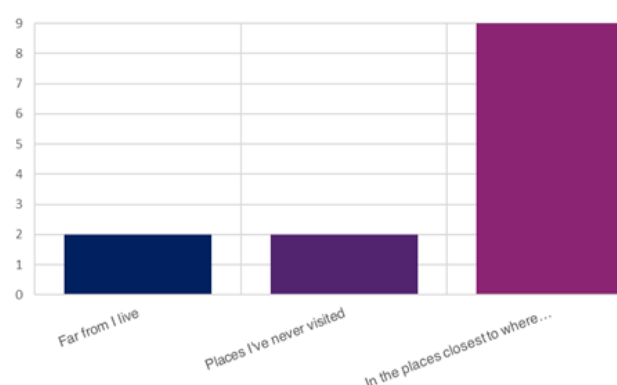


Figure M37: Where did you collect data?

Volunteers suggested some ideas that could help improve the initiative in the future. Compatibly with the pandemic situation, they would like to have more opportunities to meet in person and practice on the data collection activities. They would appreciate a widening of the monitoring area within the natural reserve to have new areas to explore and examine. And in the meantime, they would like to be more guided in reaching the observation points, especially the one most remote and less accessible. They suggest improving the questionnaire used for the data collection, to make it simpler and more intuitive and flexible.

They suggest trying to engage more people to increase the awareness about the topic (e.g. involving university students in environmental fields) and to try to build a permanent and open community aiming at monitoring the natural reserve.

They believe the care of the natural reserve could be improved by the planning of events that could involve more categories of people, for example schools and families. Some suggested events are: talks for dissemination of results, courses to learn how to recognize plants and animals of the natural reserve, trekking in the natural reserve for picking up litter or for taking care of plants, campaigns for monitoring water, guided tours with a specific topic (e.g. the river, the moist areas, flowers, poisonous weeds and edible herbs, etc....) wildlife photo contests or short films contests to tell about the natural reserve or festive events with low environmental impact (e.g. folk dancing...).

The restrictions imposed by the pandemic situation represented a partial limitation only for 5 out of 13 respondents. For 3 respondents the project activities were even seen as an excuse to go out from home during the pandemic situation (cf. Figure M38).

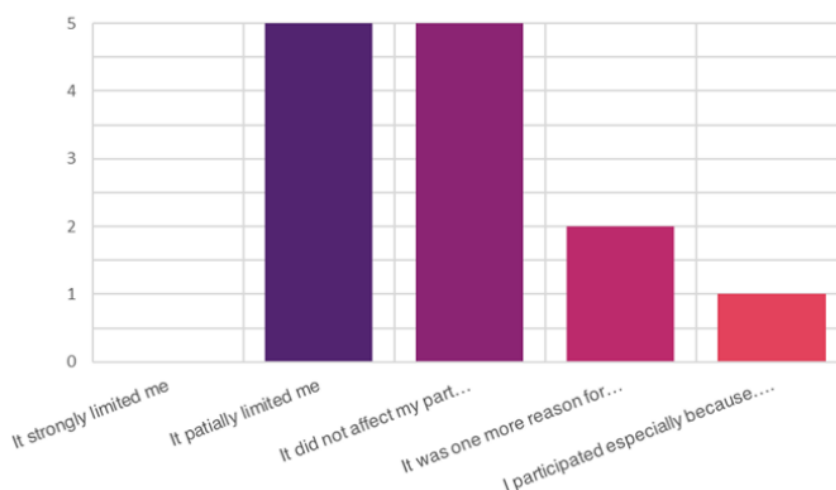


Figure M38: How does the pandemic situation influence your participation in the project?

Participants were very motivated to participate in the project's activities since the average value of global motivation is 4.31 on a scale of 5 (cf. Figure M39).

Curiosity and love for nature and the desire to protect the natural reserve are some of the reasons that encouraged volunteers to take part in the project (words "curiosità" = "curiosity", "riserva" = "reserve", "contribuire" = "contribute", "natura" = "nature" in the word cloud of Figure M40). Volunteers wanted to spend time in the open air and in the meantime learning new things about environmental topics and discovering new places (words "nuove" = "new", "aree" = "areas", "aperta" = "open air"). Volunteers were also driven by the desire to protect the river and the environment of the neighbourhood where they live. They wanted to support scientific research and to contribute to do something useful for environmental conservation and for the next generations (words "utile" = "useful", "ambiente" = "environment", "conoscere" = "to know").



Figure M39: How much are you motivated in participating in the Walk Up Aniene project?



Figure M40: In your own words, what is the main motivation why you decided to participate in the Walk Up Aniene project? The most voted were new, useful.

Mapping Mobility

Mapping Mobility is a citizen science community with 8 active participants focused on fighting air pollution, based in Rugeley, Staffordshire (England). The pilot is led by the Institute for Sustainable Futures at Keele University.

The project's idea was to engage citizens in collecting spatially referenced mobility data pertaining to their patterns of active travel within their community. The goal was to use the outputs from this data to encourage and educate their community and local authorities about sustainable travel opportunities/barriers for the town, thus tackling issues of local transport-related pollution.

The project aimed to involve volunteers in the data collection by mapping the quality of local routes. Citizen scientists were also involved in the analysis and interpretation of data collected. They were trained as to how to collect, analyse and generate visualisations using a Geographic Information Systems approach. The data were produced by the community for the community to encourage modal shifts in travel.

The survey flow was split in 3 branches in order to customise each branch according to the role of the volunteers in the project: data collector, community engager and data analyst.

Since we collected only one filling of the survey (from a data collector volunteer), we decided to not analyse this pilot in terms of motivating factors.

2.3 Analysis of motivating factors

The quantitative analysis for investigating the Schwartz motivating factors (Schwartz, 2012) that drives volunteers in participating in citizen scientists' campaigns consists in evaluating the basic statistics (mean and variance) for each question of the survey and for each motivating factor. The

analysis of means indicates which factors are more or less important to volunteers, while the analysis of variances give an indication of the heterogeneity of opinions among respondents: low values of variances denote those respondents are almost aligned on the same rating whereas values of variances higher than 1 are an indication of divergent opinions.

The second analysis performed is the computation of the correlation between the answers given to each factor with the level of global motivation indicated by the respondents. The goal is to study the relationships between motivating factors and global motivation in order to discover which motivating factors play a significant role in each specific scenario.

2.3.1 Analysis of means and variances

Table M4 and Table M5 show the means and the variances for respectively each motivating factor and each question. The values of all the answers range from 1 to 5. We reported in both tables the data collected with the TESS Network Community, already described in Deliverable 5.6, for comparison.

| | OPEN SOIL ATLAS | | RESTART DATA WORKBENCH | | WALK UP ANIENE | | WATER SENTINELS | | WOW NATURE | | TESS | |
|-------------------|--------------------|-------------|---------------------------|-------------|-------------------|-------------|--------------------|-------------|---------------|-------------|------|-------------|
| | Mean | Var | Mean | Var | Mean | Var | Mean | Var | Mean | Var | Mean | Var |
| Achievement | 4.36 | 0.39 | 4.06 | 0.53 | 4.44 | 0.25 | 4.88 | 0.12 | 4.25 | 1 | 4.13 | 1.1 |
| Belongingness | 3.57 | 1.49 | 3.83 | 1.09 | 3.96 | 0.6 | 3.75 | 3.36 | 4.25 | 0.6 | 3.75 | 1.43 |
| Benevolence | 4 | 0.89 | 4.06 | 0.88 | 4.12 | 0.99 | 4.88 | 0.12 | 4.38 | 0.59 | 4.42 | 0.54 |
| Conformity | 2.79 | 1.26 | 1.78 | 1.36 | 1.54 | 0.74 | 2.88 | 2.7 | 1.94 | 1.13 | 2.35 | 1.84 |
| Hedonism | 3.71 | 1.14 | 4.44 | 0.73 | 4.15 | 0.62 | 4.75 | 0.5 | 3.81 | 1.5 | 4.17 | 0.79 |
| Power | 1.86 | 1.52 | 2 | 1.06 | 2.58 | 1.45 | 2 | 2.57 | 2 | 1.33 | 2.83 | 1.54 |
| Routine | 1.64 | 1.17 | 2.44 | 1.44 | 1.31 | 0.62 | 1 | 0 | 1.88 | 1.85 | 3.08 | 2.1 |
| Self-direction | 4.21 | 0.4 | 4.39 | 0.72 | 4.69 | 0.28 | 5 | 0 | 4.25 | 1 | 4.43 | 0.74 |
| Stimulation | 3.79 | 1.43 | 3.94 | 0.88 | 4.08 | 0.87 | 4.38 | 0.55 | 3.62 | 1.58 | 4.14 | 0.85 |
| Universalism | 4.04 | 0.63 | 4.39 | 0.72 | 3.92 | 1.03 | 5 | 0 | 4.12 | 0.78 | 4.33 | 0.74 |
| Global motivation | 3.93 | 0.69 | 4.33 | 0.5 | 4.31 | 0.56 | 5 | 0 | 3.75 | 1.64 | 4.39 | 0.57 |

Table M4: Mean and Variance of each motivating factor

The motivating factors that totalized very high mean values for all the pilots are *achievement*, *benevolence*, *self-direction* and *universalism*, while the factors that show the lowest mean values are *conformity*, *power* and *routine*. *Belongingness*, *hedonism* and *stimulation* are very high for some pilots and neutral for others.

Regarding the global motivation, all the pilots totalized high scores with low variances except for the Wow Nature pilot that showed a higher variability in the opinion of participants (variance 1.64) and a slightly lower mean value (3.75).

| | OPEN SOIL ATLAS | | RESTART DATA WORKBENCH | | WALK UP ANIENE | | WATER SENTINELS | | WOW NATURE | | TESS | |
|--------------------------|--------------------|-------------|------------------------------|-------------|-------------------|-------------|--------------------|-------------|---------------|-------------|------|-------------|
| | Mean | Var | Mean | Var | Mean | Var | Mean | Var | Mean | Var | Mean | Var |
| Achievement-1 | 4.21 | 0.49 | 3.89 | 0.61 | 4.46 | 0.27 | 4.75 | 0.25 | 3.88 | 1.55 | 3.79 | 1.41 |
| Achievement-2 | 4.5 | 0.27 | 4.22 | 0.44 | 4.54 | 0.27 | 5 | 0 | 4.62 | 0.27 | 4.53 | 0.54 |
| Achievement-3 (WUA) | | | | | 4.31 | 0.23 | | | | | | |
| Belongingness-1 | 3.57 | 1.49 | 3.11 | 0.86 | 3.62 | 0.59 | 2.5 | 3.67 | 3.88 | 0.7 | 3.03 | 1.3 |
| Belongingness-2 | | | 4.56 | 0.28 | 4.31 | 0.4 | 5 | 0 | 4.62 | 0.27 | 4.44 | 0.57 |
| Benevolence-1 | 4.14 | 1.05 | 4.67 | 0.25 | 4.69 | 0.23 | 5 | 0 | 4.62 | 0.55 | 4.52 | 0.41 |
| Benevolence-2 | 3.86 | 0.75 | 3.44 | 0.78 | 3.54 | 1.1 | 4.75 | 0.25 | 4.12 | 0.98 | 4.4 | 0.67 |
| Benevolence-3 (WN) | | | | | | | | | 4.38 | 0.27 | | |
| Conformity-2 | | | 1.78 | 1.94 | 1.23 | 0.36 | 2 | 4 | 1.75 | 1.36 | 1.74 | 1.26 |
| Conformity-1 | 2.79 | 1.26 | 1.78 | 0.94 | 1.85 | 0.97 | 3.75 | 0.25 | 2.12 | 0.98 | 2.86 | 1.81 |
| Hedonism-2 | | | 4.89 | 0.11 | 4.08 | 0.41 | 5 | 0 | 3.5 | 2.29 | 4.22 | 0.73 |
| Hedonism-1 | 3.71 | 1.14 | 4 | 1 | 4.23 | 0.86 | 4.5 | 1 | 4.12 | 0.7 | 4.18 | 0.86 |
| Power-1 | | | 2.56 | 1.03 | 3 | 0.67 | 3 | 3.33 | 2.75 | 1.07 | 3.47 | 0.9 |
| Power-2 | 1.86 | 1.52 | 1.44 | 0.53 | 2.15 | 1.97 | 1 | 0 | 1.25 | 0.5 | 2.17 | 1.35 |
| Routine-1 | 1.64 | 1.17 | 2.22 | 0.94 | 1.31 | 0.73 | 1 | 0 | 1.38 | 1.12 | 2.9 | 2.51 |
| Routine-2 | | | 2.67 | 2 | 1.31 | 0.56 | 1 | 0 | 2.38 | 2.27 | 3.2 | 1.68 |
| Self-direction-1 | 4.14 | 0.44 | 3.89 | 0.86 | 4.31 | 0.4 | 5 | 0 | 3.75 | 1.36 | 4.16 | 1 |
| Self-direction-2 | 4.29 | 0.37 | 4.89 | 0.11 | 4.85 | 0.14 | 5 | 0 | 4.75 | 0.21 | 4.78 | 0.3 |
| Self-direction-2.1 (WUA) | | | | | 4.92 | 0.08 | | | | | | |
| Self-direction-2.2 (WUA) | | | | | 4.46 | 0.44 | | | | | | |
| Self-direction-2.3 (WUA) | | | | | 4.92 | 0.08 | | | | | | |
| Stimulation-1 | 4.07 | 1.15 | 4 | 0.75 | 4.31 | 0.73 | 4 | 0.67 | 3.75 | 1.36 | 4.38 | 0.63 |
| Stimulation-2 | 3.5 | 1.65 | 3.89 | 1.11 | 3.85 | 0.97 | 4.75 | 0.25 | 3.5 | 2 | 3.97 | 0.99 |
| Universalism-1 | 4 | 0.77 | 4.33 | 0.75 | 3.54 | 1.1 | 5 | 0 | 4.38 | 0.55 | 4.37 | 0.63 |
| Universalism-2 | 4.07 | 0.53 | 4.44 | 0.78 | 4.31 | 0.73 | 5 | 0 | 3.88 | 0.98 | 4.37 | 0.86 |

Table M5: Mean and Variance of each question of the survey. The core questions of the motivational study are highlighted in black whereas the questions added only to some specific pilots are highlighted in blue.

What is common to all the pilots is that volunteers decide to participate because the project is an opportunity to do something meaningful (*achievement-2*) and because they want to feel part of something worthwhile (*belongingness-2*). Participation in the project is also seen as a good thing to do (*benevolence-1*). Volunteers are very interested in the topics addressed by the project (*self-direction-2*) and so they expect also to learn from their participation (*self-direction-1*). They are stimulated by the possibility to do something new (*stimulation-1*) but only in some cases this represents an opportunity to challenge themselves (*stimulation-2*). Citizen scientists are passionate about the project (*hedonism-2*) and participating makes them also feel good about themselves (*hedonism-1*). They also contribute to the possibility of making data more accessible (*universalism-1*) and to help raise public awareness of the project's topics (*universalism-2*). They do not expect anything in return (*power-2*) and they do not contribute to gain status or recognition (*power-1*). They were not obliged to participate (*conformity-2*) and they often took part in the project even if they didn't know other people of the community in advance (*conformity-1*). They are

almost neutral to the possibility of meeting people with similar interests by participating in the citizen science campaign (*belongingness-1*). Most participants interviewed were not used to participating in similar citizen science projects and they have never done similar tasks before (*routine-1* and *routine-2*).

2.3.2 Analysis of correlation

The analysis of means and variances can be combined with the analysis of correlation between the global motivation and each motivating factor, as shown in Table M6. The level of significance of the correlation (p-value) is indicated by the stars next to the figures: *** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05. Values of correlation higher (lesser) than 0.70 (-0.70) can be considered high positive (negative) correlations, values between 0.50 and 0.70 (-0.50 and -0.70) moderate positive (negative) correlations and values between 0.30 and 0.50 (-0.30 and -0.50) low positive (negative) correlations. It was not possible to calculate the correlations for the Water Sentinels pilot due to the very small dataset available (data from only 4 respondents).

| | OPEN SOIL ATLAS | RESTART DATA WORKBENCH | WALK UP ANIENE | WOW NATURE | TESS |
|----------------|--------------------|---------------------------|-------------------|------------|----------|
| Achievement | 0.322 | 0.371 | 0.354 | 0.766* | 0.424*** |
| Belongingness | 0.423 | 0.204 | 0.496 | 0.834* | 0.456*** |
| Benevolence | 0.532* | 0.101 | 0.636* | -0.177 | 0.62*** |
| Conformity | -0.183 | -0.053 | 0.069 | -0.707* | 0.075 |
| Hedonism | 0.67** | 0.559 | 0.677* | 0.925** | 0.588*** |
| Power | 0.366 | -0.213 | -0.404 | 0.73* | 0.156 |
| Routine | -0.116 | 0.029 | -0.266 | -0.727* | 0.272* |
| Self-direction | 0.265 | 0.755* | 0.58* | 0.946*** | 0.491*** |
| Stimulation | 0.643* | 0.682* | 0.239 | 0.872** | 0.423*** |
| Universalism | 0.564* | 0.465 | 0.619* | 0.162 | 0.672*** |

Table M6: Correlations between each motivating factors and the global motivation

Table M6 shows that the correlations of the motivating factors with the global motivation are not the same for all the pilots, but there are some commonalities between some pilots. This is the case of Open Soil Atlas, Walk Up Aniène and TESS that all have a moderate positive correlation for the *benevolence*, *hedonism* and *universalism* factors. Restart Data Workbench shows a different behaviour, with moderate-high correlations for the *self-direction* and *stimulation* factors. Different again are the correlations of the Wow Nature pilot: all the factors have strong positive correlations except for the *conformity* and *routine* factors that are negatively correlated and the *benevolence* and the *universalism* which do not show any correlation with the global motivation.

Overall, the factors that are positively correlated with almost all the pilots are *hedonism*, *self-direction* and *stimulation*, indicating that what mainly motivates volunteers in general is the possibility to be stimulated in doing and learning something new, the opportunity to do something that make them feel good about themselves and to contribute to a project that they are passionate about.

2.3.3 Differences between pilots

In the following we analyse the pilots by highlighting commonalities and differences between citizen scientist initiatives operating in different contexts.

Open Soil Atlas, Walk Up Aniene and TESS

Open Soil Atlas, Walk Up Aniene and TESS have positive moderate correlations with the same motivating factors: *benevolence*, *hedonism* and *universalism*. This means that the volunteers who show a strong willingness in contributing to scientific research (raise awareness and make data accessible), who are very passionate about the topic of the campaign and who see their participation as a good thing to do are also very motivated to participate in the project. The data and the scientific aspects are very important for all the 3 pilots since all the volunteers are all involved in data collection task: TESS volunteers collect data by hosting and installing sensors that measure the level of sky brightness, Open Soil Atlas participants do measurements on the field about the soil characteristics and Walk Up Aniene volunteers collect environmental observation in a natural reserve to map environmental criticalities.

One difference between the three pilots is that the motivation of the Open Soil Atlas volunteers is also correlated with the willingness of doing something new and of challenging themselves (*stimulation factor*). This is reasonable since volunteers, in preparation for the data collection task, were taught about the soil testing protocol (how to make observations, test the soil, interpret results and draw conclusions) through free workshops and online materials.

By looking at the mean values of the factors and questions, we notice another difference for the *routine* dimension. The *routine* mean of the TESS pilot (3.08) is higher than the means of the other two pilots (mean = 1.64 for Open Soil Atlas and mean = 1.31 for Walk Up Aniene) indicating that some volunteers of TESS (high variance = 2.1) have some expertise in this kind of citizen science tasks and have already done sky brightness measurements before joining this community.

Restart Data Workbench

The motivation of participants of Restart Data Workbench is highly correlated with the *self-direction* and *stimulation* dimensions. This means that the motivation of volunteers is related to their interest in the topics of the campaign and to the possibility of learning while being stimulated in doing something new. The interest and the passion for the soil pollution and waste reduction/management topics are confirmed by the mean scores obtained in the *Hedonism-2* and *Self-direction-2* questions (both mean values 4.89 with very low variances).

Restart Data Workbench is an online community that mainly performs quick tasks or online events in which volunteers are asked to label, analyse and collect data. This focus on data is reflected in the high scores of the *Universalism* dimension, which indicates the willing to participate for making data more accessible (mean = 4.33 and variance = 0.75) and for raising awareness (mean = 4.44 and variance = 0.78) about the topic of soil pollution and waste reduction/management. They participated also because they considered it a good thing to do (mean = 4.67) and by joining the community, they felt part of something worthwhile (mean = 4.56).

Differently from the other pilots, some volunteers of Restart Data Workbench have some experience with citizen science projects related to soil pollution topics and have already done this kind of tasks before (*Routine* factor with mean = 2.67 and variance = 2).

Wow Nature

All the factors are significantly correlated with global motivation except for *benevolence* and *universalism*. The strongest correlations are with *self-direction* (0.946***), *hedonism* (0.925**) and *stimulation* (0.872**) factors. Wow Nature is the only pilot which shows a strong negative correlation between global motivation and both *conformity* and *routine* (see Table M6). This means that the higher the global motivation the lower the degree of obligation in participating in the project and the number of people already involved in the project known in advance. In addition, the more motivated people are the ones that have never participated in this kind of citizen science project before.

All the volunteers perceived the usefulness of the task performed (achievement-2 mean = 4.62 and variance = 0.27) and appreciated the idea of being part of a community which do something worthwhile (belongingness-2 mean = 4.62, variance = 0.27 and benevolence-1 mean = 4.62, variance = 0.55). This may be due to the involvement of the volunteers in all the phases of the project (from the identification of location for sensors, to their installation and monitoring, to the dissemination of the results). Doing so the volunteers are more aware of the goals of the project and feel themselves key protagonists in the fight against air pollution through the enhancement of the forests.

Most of the motivating factors listed in Table M4 have high variances, indicating heterogeneity in the opinion of participants. This may be due both to the small number of answers collected (only 8) and to the different categories of citizens involved (members of environmental associations, ONG, associations with training purposes and staff of a public institution) that may have different backgrounds and goals. More answers would be required to draw more general conclusions.

Water Sentinels

Since the volunteers actively involved in the project were only 4, the dataset available for the analysis is quite small (only 4 answers). The correlation analysis can't be done with this dataset since all the participants answer the same value for the global motivation questions and this prevents the calculation of the correlation coefficient. Therefore, we can only analyse answers by looking at the mean and variance values.

Data collected are quite homogeneous as indicated by the variances equal to 0 for most of the questions. This means that in many cases volunteers all agree on the same rating.

Differently from other projects, the *conformity-1* question has a mean value of 3.75, much higher than the means of the other pilots. Participants of Water Sentinels know each other before joining the project and this is reasonable since the project focuses on the fishing community living near the Sado estuary. Some of them were motivated to participate by the desire to meet people with similar interests (belongingness-1 with mean 2.5 but variance = 3.67).

All the participants were highly motivated to participate (*global motivation* mean = 5 and variance =0) and they participate because they are very passionate and interested in fighting water pollution (*self-direction*: mean = 5, variance =0) with a scientific approach based on data (*universalism*: mean = 5, variance =0 and *benevolence*: mean = 4.75, variance =0.25).

The problem of polluted water that has caused many mysterious deaths in recent years is very dear to the volunteers, who daily work in close touch with the water. This is confirmed by the high scores obtained for the *achievement-2*, *benevolence-1* and *hedonism* questions (cf. Table M5).

2.4 Conclusions on the motivational study

All the participants of the pilots analysed consider themselves very motivated in participating in the citizen science projects, with an average global motivation higher than 4 on a scale ranging from 1 to 5. The motivating factors that are more correlated with the global motivation in almost all the pilots are the *hedonism*, the *self-direction* and the *stimulation*, indicating that what mainly excite volunteers is the possibility of doing and learning something new and to contribute to a project that they are passionate about and that make them feel good about themselves. In general, volunteers are not at all forced to participate and they do not expect anything in return from their participation (low values in *conformity* and *power* in all the pilots).

However, there are some differences between pilots both in terms of factors correlated with the global motivation and scores assigned to each motivating factor which depend on the different contexts of the pilots. Citizens could be involved in different tasks (only data collection phase or more than one phase of the participatory science lifecycle) and with different levels of engagement; the community could be set up at a local level or at worldwide level as in the case of online communities (like Restart Data Workbench); volunteers could be directly affected by the pollution problem as for Water Sentinels volunteers who daily work with polluted water; the attention of volunteers could be more or less focused on data according to the type of activities they are involved in.

The analysis performed on the six pilots allowed us to analyse in detail the motivation of volunteers of the different pilots, but more data and more use cases would be analysed to draw more general conclusions and guidelines about what drives motivation in different contexts. This work represents a good starting point for further studies about motivations in citizen science projects. The proposed methodology for investigating the drivers of human behaviours inside communities of citizen scientists through surveys is easily reproducible and adaptable to new citizen scientists' communities. Details on the analysis performed are grouped in Research Objects, which are described in the D4.7 (Gonzalez et al., 2022).

3 DBC COMMUNITY ENGAGEMENT ANALYSIS

Dutch Butterfly Conservation was founded in 1983, and aims to conserve and restore the Dutch butterfly, moth, and dragonfly fauna. DBC carries out research with the help of volunteers, who count the insect population on a certain route on a weekly basis. The data and analysis of this data is highly valued in the Netherlands, as it is used as part of the official biodiversity measurements that subsequently inform policy. We are particularly interested in the DBC citizen science community, because the volunteers engage in the project for a very long time, up to 30 years. We analysed motivations for joining DBC as part of a larger study about community engagement in this citizen science project. This analysis complements an earlier analysis which can be seen in deliverable D 5.6.

3.1 Methodology

We distributed a questionnaire to DBC volunteers that was filled out by eighty participants. Participants answered questions about the year they started participating, what motivated them to take part in the project, their previous relevant knowledge and experience, what they like best about participating, and demographic data such as age, gender, and educational background.

The response options for the motivations and relevant knowledge and experiences were pre-categorised, with response options of 'none/not at all', 'some/somewhat', and 'very much. The question about what they like best about participating was open. The researchers conducted a deductive analysis that yielded eight categories. The data was anonymised.

In addition, we conducted six semi-structured interviews with DBC volunteer coordinators. These interviews were conducted online or in person, and asked questions around three topics: why the coordinators thought DBC volunteers participate, what their strategies and methods are for engaging volunteers, and what their goals are in terms of volunteer participation. The data was pseudonymised.

For the first topic, we marked the data that supported answers that the volunteers gave in the questionnaire, and also indicated data that was not directly supported by or in contrast with the data from the questionnaire. We coded the answers related to the second and third topic deductively and will report on the results in the next section.

3.2 Results

3.2.1 Motivational analysis

When asked about motivations for taking part in the DBC project, a clear majority answered that they very much support the goals of the project, that they are interested in the research, and that they want to contribute to the research (see Figure D1). Also a majority of the volunteers indicated that they were interested in what they contributed specifically. The response to 'I have a personal relation to the project or team' as a motivating factor was quite evenly split among the response options. Enjoying the competition with other volunteers and being rewarded for their contributions

did not appear to be a motivating factor for taking part in the project. Twelve volunteers did not answer the question fully (but partial data was included in the analysis).

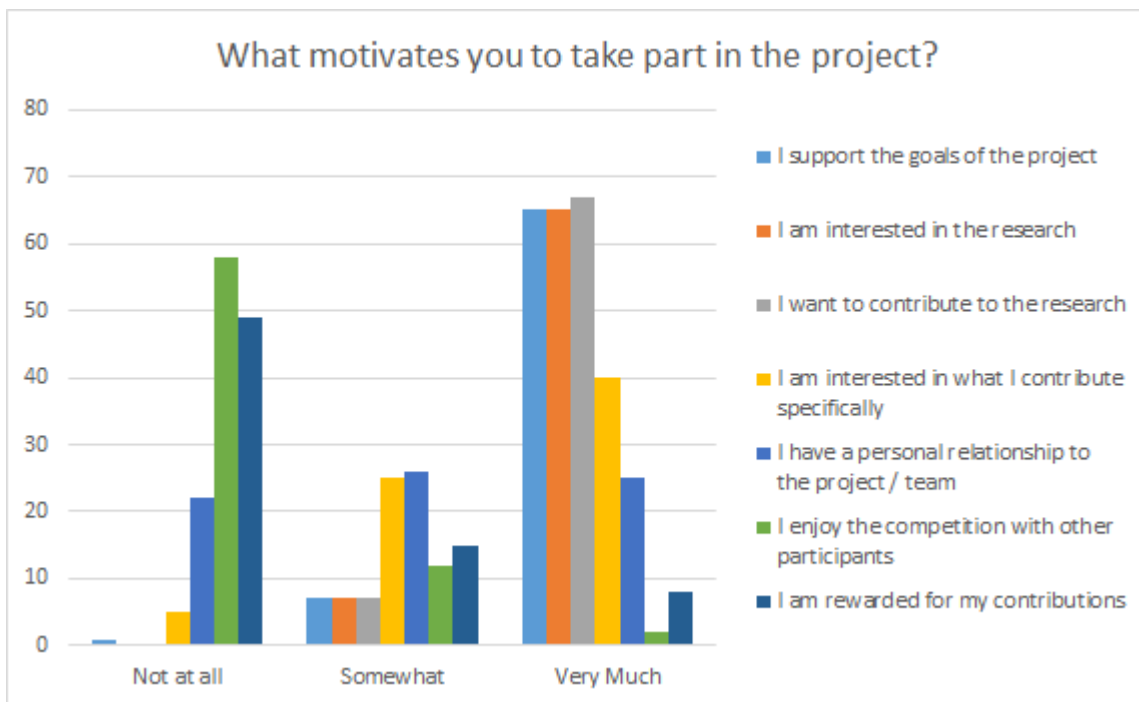


Figure D1: Importance of motivations for participating in the DBC project

3.2.2 Prior experience

Of the eighty volunteers, a majority indicated that they had previous experience with or knowledge of volunteer work, wildlife observations, and/or butterflies, moths, or dragonflies (see figure D2). The answers to the question whether they had previous experience with citizen science was more split in terms of responses. Four volunteers had some missing values (but partial data was included in the analysis).

When comparing answers to the four categories for each volunteer, we found that only three volunteers answered 'none at all' for all four categories. Furthermore, 23 participants answered 'not at all' or 'somewhat' to all of the four categories, and 57 indicated that they had 'very much' experience in at least one of the four categories.

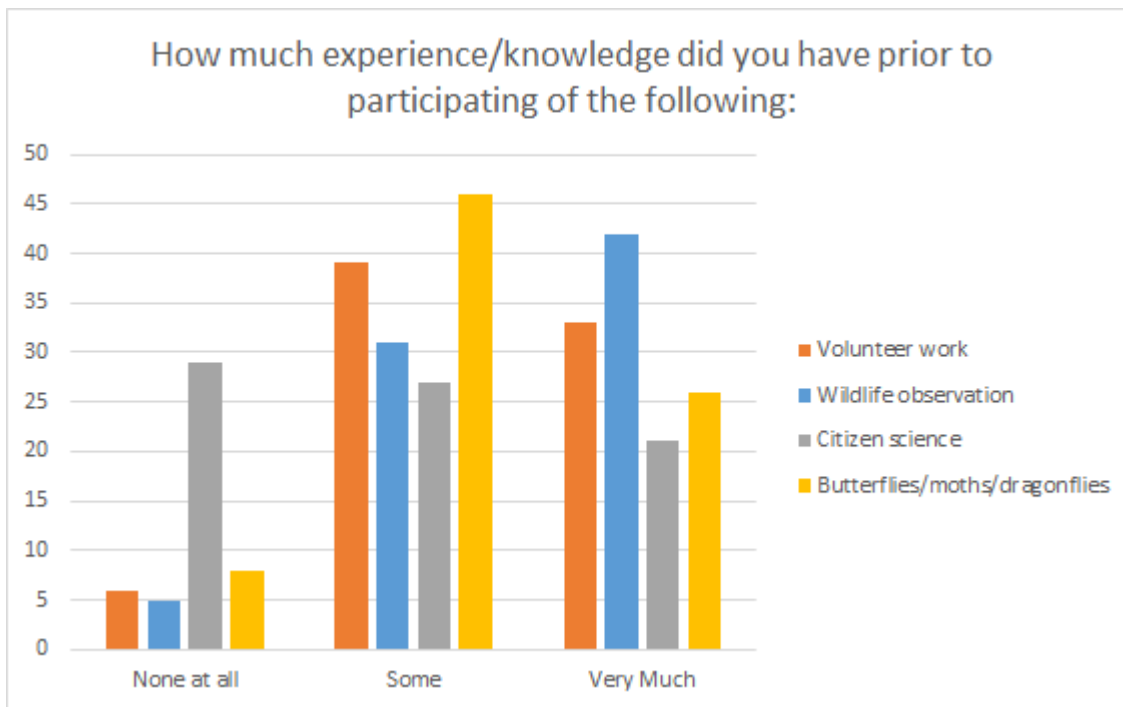


Figure D2: Volunteers' previous experience

3.2.3 Project preferences (what they like about the project)

A total of 73 volunteers completed the open question of what they like best about participating (see figure D3). Some volunteers gave a multifaceted answer, so we allowed several codes per answer. Deductive coding yielded eight categories: being in nature (22 volunteers), that they contributed to conservation of the species through a form of activism (18), contribution to research (17), an interest in the species (17), enjoyment of counting (12), being able to do fieldwork (5), enjoyment of the social aspects (3), and learning new skills (2).

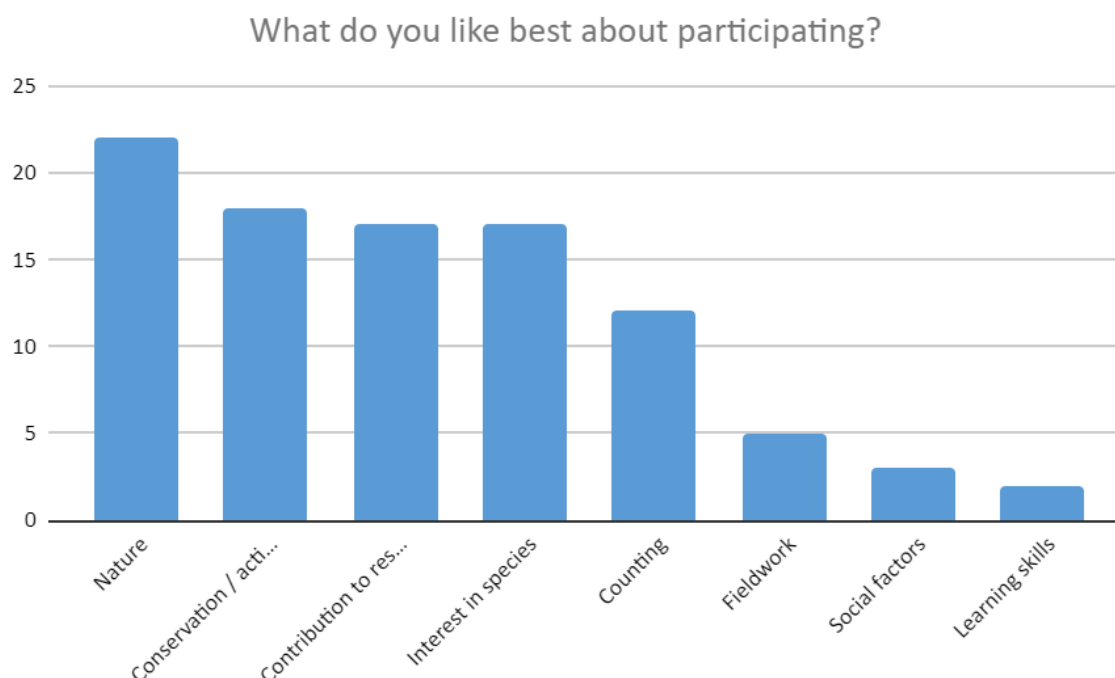


Figure D3: Volunteers' project preferences

3.2.4 Volunteer coordinators' reflections

Reasons for participation

The reasons for participating in the project that the volunteer coordinators cited mostly overlapped with what volunteers themselves indicated in the questionnaire. The coordinators suggested that volunteers like walking in nature, that they are interested in science, that they are interested in the species, that they enjoy making lists, and want to obtain data for lobbying politicians for the conservation of the species. All of these aspects align with the results displayed in section 3.6.

In addition, the coordinators mentioned reasons for participation that were not indicated in the volunteer questionnaires. The coordinators suggest that the participants already have similar hobbies, such as photography or birdwatching, which makes participation in the project relatively low-threshold. Similarly, they propose that volunteers who count on a route close to them, volunteer for a longer time, because the counting activity fits their daily activities. Also related, the coordinators say that some people have a connection to the route or location that they are asked to monitor.

Some reasons that the coordinators cite, do not seem to align with the results from the questionnaire. The coordinators suggest that personal contact among peers, and contact with the coordinators increase long-term participation. In addition, they mention that some volunteers participate because they identify with the existing group of volunteers. Interestingly, social factors are only mentioned by three of 73 volunteers in response to the question about what aspects about the project they like most. We will come back to this apparent discrepancy in the discussion.

Strategies for increasing participation and goals

The strategies that the volunteer coordinators use for increasing participation fall into six categories: personal on-boarding, task personalisation, increasing appreciation and importance, to have good communication between the project team and volunteers, to support social contact between volunteers, and to increase self-efficacy. Below we describe how DBC implements each strategy, according to the volunteer coordinators.

The on-boarding process for new volunteers is very extensive: the coordinators or DBC visit each new volunteer personally. They see what interests them, gauge how much experience they have, and provide learning materials if they need to know more. Furthermore, they talk to the new volunteer about why their contribution is so valuable, and important to the DBC and for conserving the butterflies, moths, or dragonflies.

These home visits strengthen another strategy: task personalisation. The coordinators try to find routes for volunteers that are close to their home, and more generally try to find tasks that fit their lives easily and align with their interests. Furthermore, the coordinators actively support volunteers that want to take on more responsible tasks, such as organising lectures, helping to resolve issues with land access or management issues with the land owners, helping to make local atlases of the species, or to serve as a contact point for other volunteers.

Giving volunteers more responsibility can also be part of another strategy: to make sure volunteers feel appreciated and important. DBC volunteer coordinators implement this strategy also in other ways: by sending compliments to volunteers that gather a lot of data, through email or by card for those who submit on paper. In addition, DBC makes sure to convey how important the work is that the volunteers do, by elaborating on how the data is used in yearly volunteer meetings, and by sending volunteers the results of the monitoring activities. Last, DBC coordinators always refer to participants as volunteers, rather than amateur scientists, and similarly never refer to themselves as professionals, because this could undermine the volunteers' authority.

Good communication with volunteers is generally important to the DBC volunteer coordinators. They are active on the facebook group, posting messages but also liking and commenting on posts of volunteers. They also regularly send out a newsletter to the volunteers.

Fifth, the volunteer coordinators stimulate social contact between volunteers. The yearly volunteer meeting in which there are video's, lectures, etc on the work that DBC does, is attended by over 600 volunteers. In collaboration with the work groups, they also organise more local meet-ups of volunteers.

Last, increasing self-efficacy is a strategy that makes sure that people feel apt to do the task they are asked to do. DBC coordinators find it important to give instructions that are very clear and easy to understand. Furthermore, they try to make it very easy for volunteers to approach them in case of questions, and also directly contact a volunteer that has missed a few contributions to try and motivate them.

To the question of what their goals were for participation at DBC, the volunteer coordinators were clear: they want to engage more participants, and want to make sure that the volunteers engage long-term.

3.3 Discussion & conclusion

The motivations that DBC volunteers indicate as very relevant, align well with insights in the motivational literature. DBC volunteers state that they support the goals of the project, that they are interested in the research, and that they want to contribute to the research. This aligns with other motivational research in citizen science, which proposes that the motivations most often described are *learning* (Dem et al 2018; Richter et al, 2018; Rotman et al 2012; Domroese & Johnson 2017; He et al 2019), *being involved in science* (Dem et al 2018; Domroese & Johnson 2017), to *support achieving the project's goal(s)* (Richter 2018; Land-Zandstra et al 2016; Raddick et al 2013; Curtis 2015; He et al 2019), and *interest in topic* (Land-Zandstra et al 2016; Rotman et al 2012; Rotman et al 2014; Raddick et al 2013; Curtis 2015; Aucott et al 2019).

The volunteers' response that they are very much interested in what they contribute themselves, is interesting, as it is not that often found in the literature. We hypothesise that this has to do with the specific place-based nature of the project contributions. Volunteers count insects along a specific route, which is often close to their home. It could well be that volunteers are or become attached to this route, and are interested to know if the population of insects changes in that place. This would align well with what Aucott et al. (2019) describe; that in a citizen science project about map transcription, volunteers were motivated by personal interest in places that held meaning for them, and how these places had changed.

The motivations that were seen as less relevant by DBC volunteers are social motivations, and extrinsic, reward-based motivations. These also align with project characteristics, as the counting activities are quite solitary, and there are no competitive or reward-based elements. In addition, this aligns with findings that for long-term participation - which is prevalent among DBC volunteers -, intrinsic motivations are more important than external motivations (Rotman et al. 2012).

Many DBC volunteers had previous experience with the topic and/or with volunteering. This is in line with literature, which found that the majority of participants had engaged in other citizen science projects or had been involved in environmental volunteer work (Church et al, 2019). Others have also found that prior experience with citizen science was correlated to persistence (Frensley, 2017), and that it is easier to recruit participants with related interests and prior involvement in similar activities (Everett & Geoghegan, 2016).

We found that project preferences are largely in line with the motivations for joining the project: that support the goals of the project, that they are interested in the research, and that they want to contribute to the research. In addition, they cite some project-specific factors that they like, such as being in nature, and the activity of counting.

Volunteer coordinator's reflections are in line with volunteers' motivations and preferences, with one interesting exception: while the coordinators emphasise social interaction, for example during their yearly convention, and during the onboarding process, this is hardly mentioned by volunteers.

When looking at the strategies for increasing participation, we see that DBC has an unusually involved onboarding process, where coordinators and/or other volunteers come to someone's house to onboard them. We hypothesise that this process could be crucial in ensuring long participation in the project.

We conclude that in general, motivations and preferences of DBC volunteers are collective, and align well with the most important motivations found in the literature. The hypothesis that the interest in their own contributions has underlying place-based reasons deserves further scrutiny, especially because it might be a contributing factor for DBC volunteers to engage with the project for such a long time.

4 THE IMPACT OF TASK EXPECTATIONS

While collecting data from Citizen Science and more in general in crowdsourcing exercises, contributor motivations are a key aspect to be taken into account. As known from the literature, and from the first study in this deliverable, personal motivation is affected by several external factors (**Ryan et al, 2000**). One of them is personal expectation since it affects contributors' experience, influencing their degree of satisfaction, confidence and more in general mental state. In this section we present a study to investigate how contributors' expectations impact on their experience and results.

4.1 The role of expectations

In the context of the study of the contributors' motivations, we performed crowdsourcing experiments to investigate how the presence of prior results and expectations influences contributors' motivations and behaviour. Thus we designed a crowdsourcing task in which we first created a strong, clear expectation of what the results should look like. We communicated those expectations to contributors in the task instructions. Nevertheless, we designed the task in such a way that these expectations could not be satisfied and analysed how contributors behaved while dealing with unmatched expectations. We recruited contributors from the Prolific⁷ crowdsourcing platform, which is a common way to obtain high quality annotators for controlled scientific studies.

The task workflow is as follows: After reading the instructions, contributors were required to roll a pair of dice at least 15 times and to report the sum of the two outcomes after each roll. The distribution of the expected outcome scores follows a known pyramidal distribution, as shown in Figure E1. This statistical explanation was well detailed to the contributors in the task instructions, using examples and graphical representation.

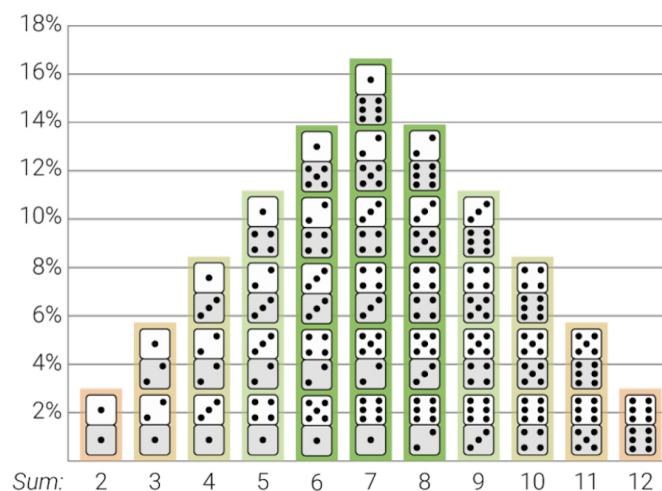


Figure E1: Expected distribution of two dice outcomes sums

Moreover, we loaded the two dice provided to contributors to produce a distribution different than the expected ones and observed the contributors' behaviour when the dice outcomes did not meet

⁷ Prolific website: <https://prolific.co/>

the statistical expectation. Figure E2 shows the distributions of outcome sums actually obtained after the first 15 rolls.

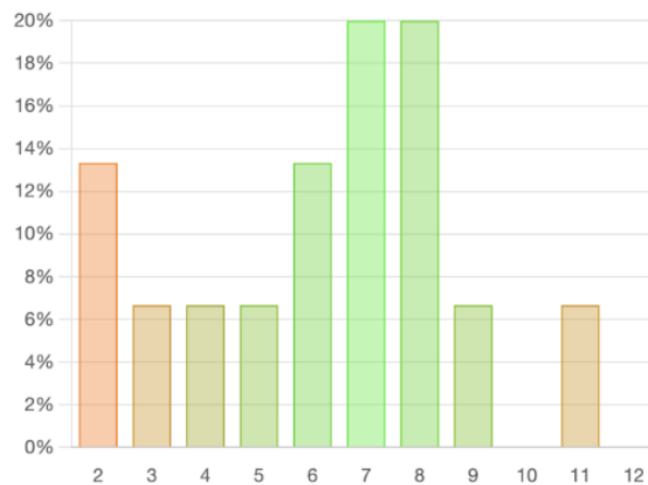


Figure E2: Distribution of two dice outcomes sums with the loaded dice

At the end of the 15 mandatory rolls, contributors could decide either to (i) complete the task and get rewarded, (ii) provide additional roll outcomes, assuming that the new rolls might result in a distribution that was more similar to the expected distribution, or (iii) cheating, reporting fake rolls that did not occur, to accommodate requesters' expectations but reducing their accuracy.

In our work we called contributors who submitted only the 15 mandatory outcome sums *Pragmatic* and those who voluntarily submitted more sums *Proactive*. The experiment results show an overall majority of Proactive contributors, consistently for both internal (14 pragmatic and 36 proactive) and external (12 pragmatic and 38 proactive) roller experiments. Also, the results show the presence of some contributors, in particular those who used the internal roller, who adapt the dice outcomes of the dice to match the statistical expectations, thus reducing their accuracy to gratify the requester expectations. The study was published at the BHCC2021 (Third symposium on Biases in Human Computation and Crowdsourcing), and presented online on 10th November 2021. The full paper can be downloaded at this link: <https://www.bhcc-symposium.com/program/full-schedule>.

4.2 Survey on expectations

The study detailed in the previous section focuses on identifying and quantifying the effect that strong expectations have on contributors' behaviour. To investigate motivational factors in the study, at the end of the task before submitting the final data, we required contributors to participate in a survey. Questions concerned both the contributors' task experience, and contributors' familiarity with statistics more generally. Figure E6, in the appendix, shows a screenshot of the survey as seen by the contributors. In the top of the survey we show side-by-side the two distributions: the expected one (on the left) and the reported one (on the right). Then, the survey presented five questions. We report below the five questions together with their responses:

- Q1: *The sequence of dice outcomes is compatible with the expectations* (Responses in 7-levels Likert scale, from *Completely disagree* to *Totally agree*).

The first question focuses on the contributors' global level of satisfaction with respect to the results submitted. As said, the dice were loaded to avoid results being too similar to the expected ones. However, as shown in the first two boxes in Figure E3, the majority of the contributors tended to be happy with the final outcome sequence obtained with a reported median agreement to the question between five and six out of seven. This suggests that contributors are aware that meeting statistical expectations might need bigger samples.

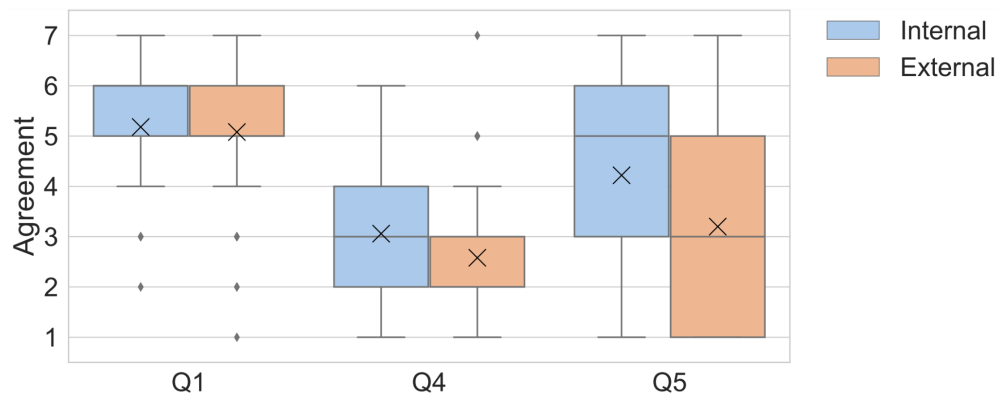


Figure E3: Contributor responses for Q1, Q4, and Q5. These are presented together because they all use Likert scale survey questions.

- Q2: *Why do you think you got these results? Any thoughts are welcome* (Responses in free text).

The second question investigated the reasons that contributors impute to justify/describe the results they obtained. We manually analysed the responses provided by the 100 workers to identify the more recurrent tags, intended as concepts expressed, and then we counted the number of answers where they appear. The recurrent tags we found were:

- *Left skewed*: the contributors noticed a larger presence of small numbers in the outcomes sequence;
- *Over probability of number 2*, the contributors notice that the number two occurred more times than expected;
- *Bell shaped*, the contributors noticed the typical bell shape of the outcomes distributions;
- *Randomness/Coincidence*, the contributors impute to random factors the shape obtained outcomes distribution;
- *Undecided / Unknown*, the contributors cannot identify any reason to explain/describe the shape of the obtained sequence;
- *Trust / Conspiracy*, the contributors believe dice were loaded or the task was somehow designed for a hidden purpose;
- *Distribution as expected*, the contributors are happy with the distribution obtained and feel satisfied;
- *Simple size effect*, the contributors mentioned the fact that the number of the dice outcomes reported is too low to match significantly statistical expectations.

- Reasonably, contributors expected that by adding dice rolls the results would converge toward statistical expectations;
- *Unhappy*, the contributors completed the task but they were unsatisfied with the results;
 - *Luck*, the contributors believed that the similarity of the outcomes distribution obtained rolling the dice with the expected distribution is due to luck;

Figure E4 shows the heatmap with the occurrence of the Q2 tags.

| | | | | |
|--------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Left skewed | 0 | 0 | 0 | 0.056 |
| Overprob. of number 2 | 0.17 | 0.026 | 0 | 0.056 |
| Bell Shaped | 0.17 | 0.45 | 0.071 | 0.31 |
| Randomness / Coincidence | 0.17 | 0.18 | 0.21 | 0.17 |
| Undecided / Unknown | 0.083 | 0.053 | 0.14 | 0.028 |
| Trust / Conspiracy | 0 | 0.079 | 0 | 0 |
| Distribution as expected | 0.083 | 0.11 | 0.21 | 0.17 |
| Sample size effect | 0.25 | 0.13 | 0.071 | 0.11 |
| Unhappy | 0 | 0.053 | 0 | 0.083 |
| Luck | 0.083 | 0.079 | 0.071 | 0.056 |
| | External Pragmatic (12 workers) | External Proactive (38 workers) | Internal Pragmatic (14 workers) | Internal Proactive (36 workers) |

Figure E4: Occurance of the more recurrent tags for Q2

- Q3: We used two versions of the third question, the first one for pragmatic contributors (a) and the second one for proactive contributors (b). In (b) we showed an example of a proactive contributor who reported 23 rolls.
 - Q3 for pragmatic contributors: *You reported exactly 15 outcomes as required, and that is great! Moreover, you had the chance to report more outcomes voluntarily, is there any particular reason because you stopped at 15?* (Responses in free text)
 - Q3 for proactive contributors: *Despite being required to report 15 outcomes, you reported 23 outcomes, which is really great. What are the reasons for that extra effort?* (Responses in free text)

The question focuses on the reasons that contributors quit the task at a given point in task execution, for both proactive and pragmatic contributors. Similarly to Q2, we identified the most recurrent tags in the collected responses.

- a. *Fun*, contributors found the task fun or enjoyable;

- b. *Unmet expectations*, contributors were unsatisfied;
- c. *Peak at 7*, contributors mentioned a pick at number 7 in the distribution;
- d. *Convergence / Large numbers*, contributors were aware the reported distribution could get closer to the expected one by increasing the number or outcomes reported;
- e. *Luck*, contributors attributed the obtained distribution to luck;
- f. *Curiosity*, the contributors found the task curious;
- g. *Bored / Tired*, contributors were too bored or tired to continue the task;
- h. *Instruction compliant*, contributors just provided the 15 mandatory results to be highly compliant to the given instructions;
- i. *Altruism / Commitment*, contributors provided additional volunteer outcomes because of a sense of commitment or altruism;
- j. *Happy / Satisfied*, contributors were satisfied with the obtained distribution.

| | | | | |
|-----------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Fun | 0 | 0.13 | 0 | 0.17 |
| Unmet expectation | 0 | 0.32 | 0 | 0.33 |
| Peak at 7 | 0 | 0.053 | 0 | 0.056 |
| Convergence / Large numbers | 0 | 0.29 | 0.071 | 0.28 |
| Luck | 0 | 0.18 | 0 | 0.083 |
| Curiosity | 0 | 0.21 | 0 | 0.33 |
| Bored / Tired | 0 | 0 | 0 | 0 |
| Instruction compliant | 0.75 | 0 | 0.5 | 0 |
| Altruism / Commitment | 0 | 0.079 | 0 | 0.19 |
| Happy / Satisfied | 0.083 | 0 | 0.21 | 0.028 |
| | External Pragmatic (12 workers) | External Proactive (38 workers) | Internal Pragmatic (14 workers) | Internal Proactive (36 workers) |

Figure E5: Occurance of the more recurrent tags for Q3

Figure E5 shows the heatmap with the occurrence of the Q3 tags.

- Q4: *I am usually pretty accurate at predicting the outcome of a dice roll* (Responses in 7-levels Likert scale, from *Completely disagree* to *Totally agree*).

In this question we do not focus on the task experience or results, but on the general contributor's belief of being capable of predicting dice outcomes. The second and third boxes of Figure E3 show that the median responses for Q3 is 3 indicating that contributors feel they are somehow able to predict the outcomes. Those who feel so might be more likely to stop rolling the dice when they predict outcomes that will not improve the

distributions toward expectations.

- Q5: *I should keep track of previous dice rolls so that I can figure out future outcomes* (Responses in 7-level Likert scale, from *Completely disagree* to *Totally agree*).

Similarly to Q4, Q5 focused on the dice outcomes predictions from contributors. This time we mentioned the previous dice outcome as a factor to be considered in the prediction of following outcomes. Despite dice outcomes being totally independent of each other, indeed each die outcome always occurs with probability of $1/6$, contributors tend to agree (median of 5 for internal and 3 for external) that tracking previous dice outcomes might somehow help in prediction of following ones. This might indicate a little understanding about stats from some contributors. This factor has to be considered while investigating the contributor motivations in providing volunteer work in presence of statistical expectations.

4.3 Discussion

The survey investigated how contributors deal in situations when things go in an unexpected way. From the original study we have seen that the contributors' behaviour can vary between individuals. Almost 25% of the contributors provided the minimum effort to complete the task, most justifying this as a matter of instruction compliance (even though instructions said 15 rolls were just the minimum amount). These contributors were either assuming results were statistically plausible or they were not particularly affected by the expectations.

The remaining ~75%, contributed more rolls than required. These were people who somehow felt the need to keep rolling the dice longer. Investigating the reasons for that, in our survey we found that the reasons for this extra effort were various. Among all of these reasons (like curiosity, sense of commitment, altruism or fun), "unmet expectation" was most mentioned by the contributors overall. Note that the second mentioned reason is the "coverage to large numbers" which is again strongly related to the statistical expectation. These results validate our intuition of the importance of expectations (both when these are met and when they are not) to the contributors' experiences and thus their behaviours.

Also, it is worth noticing that in a study like ours, which relies on a solid statistical expectation, we should not take for granted that contributors are familiar with statistics. Indeed, for example, several contributors believe that taking note of previous rolls might somehow predict the outcomes of the following dice rolls, which is unreasonable given the independence between different rolls.

5 QROWDSMITH: MOTIVATION THROUGH GAMIFICATION

Contributor engagement is a key aspect to promote participation in Citizen Science. CS initiatives often involve contests, challenges and competitions as a strategy to attract the interest of their participants (De Moor et al, 2019). Gamification is also a widely used strategy to serve that purpose (Schöbel et al, 2019; Eveleigh et al, 2013). In this section we present Qrowdsmith, a standalone tool that adopts gamification techniques to increase contributors' engagement not only for Citizen Science, but for crowdsourcing in general.

5.1 Qrowdsmith

We develop Qrowdsmith as an inhouse gamified crowdsourcing platform to test the implementation of gamification techniques aimed at improving contributor engagement. Qrowdsmith is an online platform which can be standalone and is intended for use as a black box that can operate with several task templates and crowds. For example, we can run Citizen Science campaigns with a volunteer backend, similarly to Zooniverse, in which contributors are required to annotate urban images or we can recruit contributors from a paid backend like Prolific and ask them to annotate social media content. The purpose of this study is to test the impact of the use of gamification strategies to see how these affect user engagement and the quality and quantity of the results produced by the crowd. For this purpose, we set up a crowdsourcing task to be performed by 800 unique contributors over eight experimental settings.

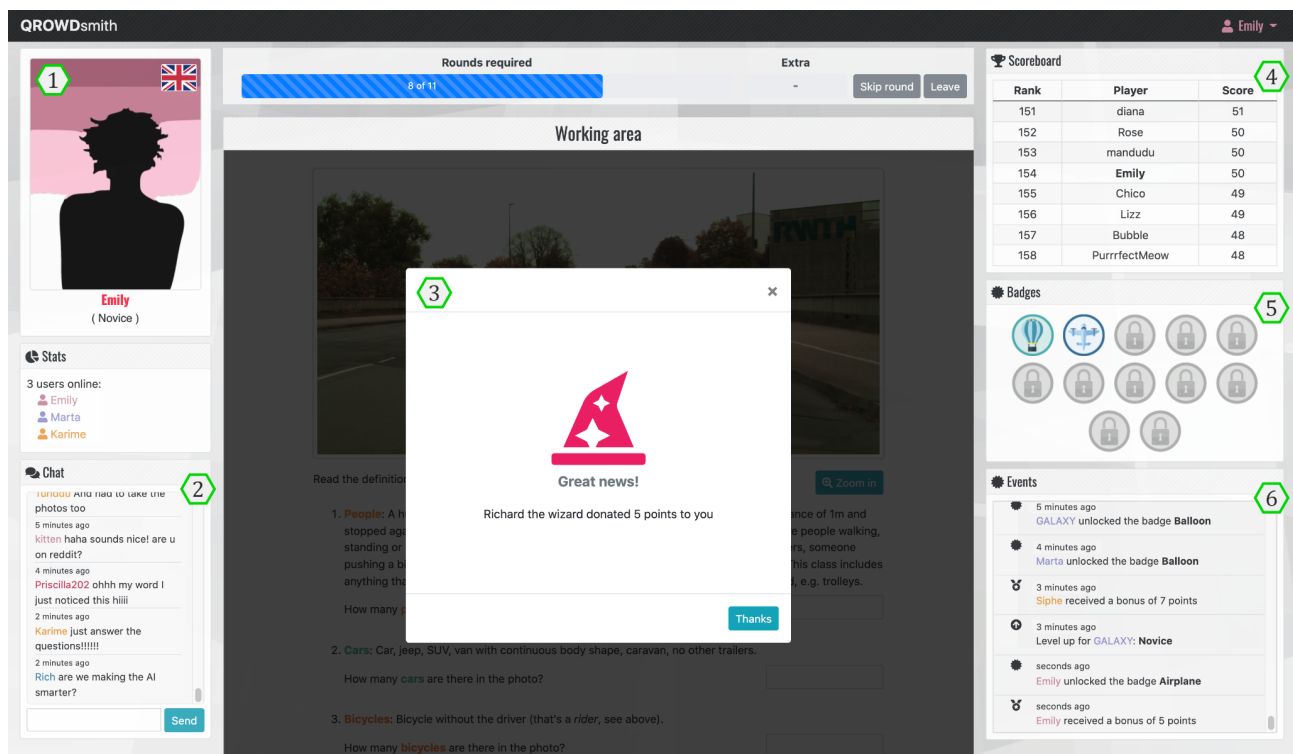


Figure Q1: Qrowdsmith interface

Qrowdsmith offers the six gamified components shown in the screenshot of the interface in Figure Q1. These are marked with green hexagons in the figure. The gamified components are the following:

1. *User profile*: a panel that can be customised with a profile picture and a national flag and shows the level of the user;
2. *Chat*, a simple chat that add interactivity to the platform;
3. *Bonuses*, prizes consisting of scoreboard points that are randomly given to users after completing some tasks;
4. *Scoreboard*, a panel that informs the users on their position on the global rank;
5. *Badges* assigned to the users at certain score thresholds;
6. *Events panel*, that informs the user about what is going on in the platform.

These six elements are a corollary of the central column, shown in Figure Q2, which has a control panel on top and a working area at the bottom. The control panel contains elements to update users about progress in the task. In particular, this shows the count of the number of rounds (unit of work - single images to annotate in this case). These are divided into mandatory (to complete the task) and extra, which are voluntary and unpaid. Also the panel includes controls to let them skip a round and to leave the task. The working area panel is the space when the user operates. Note that in a regular crowdsourcing task a worker would only see and interact in the working area. In our experiment, the task consists of annotating urban images counting the number of items of a given type. Note that this is a common type of task to create collections of annotated images to be used to train automatic annotators. Also, to have a indicator of the the quality of the users annotations, we used fine annotated images from Cityscapes⁸ as a ground truth in our experiment.

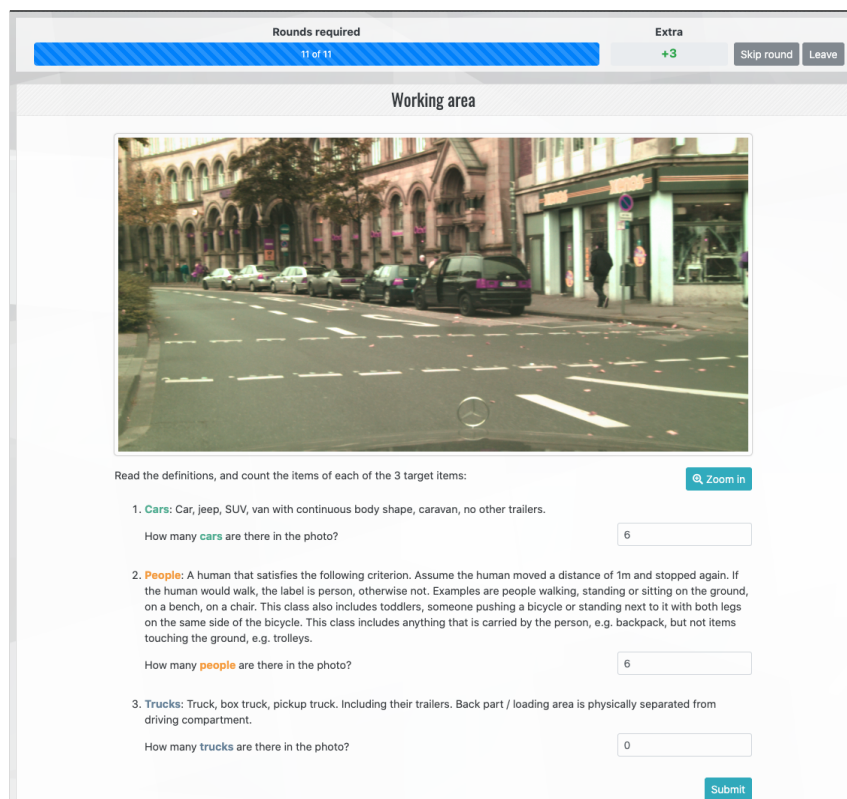


Figure Q2: The control panel and working area

⁸ Cityscapes webpage: <https://www.cityscapes-dataset.com/>

Also, we implemented four **Furtherance Incentives (FI)** in Qrowdsmith. These were offered to a worker who completed all of the mandatory rounds and clicked on the leave button. The goal of the FIs is to tempt users to remain in the platform longer, providing additional contributions. The four FIs and the prizes for their achievement were the following:

- **Special Badge (SB)** gave the users a distinctive badge to be shown alongside those already owned in the badge panel;
- **Qrowdsmith Points (QP)** gave Qrowdsmith points to the users, These might contribute the worker ranking up the scoreboard;
- **Special Power (SP)** gave the worker the ability to unveil the responses given by other users to the next ongoing rounds;
- **Monetary reward (MR)** rewarded the worker with an additional payment of .5 GBP.

5.2 Research questions

The study addressed the following four research questions:

- **RQ1**, Can furtherance incentives prompt workers to undertake more work? What are the most effective furtherance incentives?
- **RQ2**, How do furtherance incentives affect the speed at which workers perform tasks?
- **RQ3**, How do furtherance incentives affect the quality of microtask work?

5.3 Methodology

To test the effect of the use of gamification and the four FIs, we ran the experiment in eight settings. These are summarised in Table Q1. Each setting was performed by 100 users.

| Exp. Setting | Rounds required | Gamification | FI type | Extra rounds | Payment GBP |
|--------------|-----------------|--------------|---------|--------------|---------------|
| 0.1 | 1 | - | - | - | .2 |
| 0.11 | 11 | - | - | - | .5 |
| 1.1 | 1 | ✓ | - | - | .2 |
| 1.11 | 11 | ✓ | - | - | .5 |
| 2.11 SB | 11 | ✓ | SB | 11 | .5 |
| 2.11 QP | 11 | ✓ | QP | 11 | .5 |
| 2.11 SP | 11 | ✓ | SP | 11 | .5 |
| 2.11 MR | 11 | ✓ | MR | 11 | .5 + .5 bonus |

Table Q1: The eight experiment settings

For convenience, we label each round submitted by users as:



- ***m***, the initial mandatory paid rounds. Their number is specified by the FI;
- ***e***, the voluntary rounds a worker can submit after the those of type ***m***;
- ***f***, the voluntary rounds performed after a FI is offered, until it is achieved, namely when the user submits 11 rounds of type ***f***;
- ***x***, the voluntary rounds performed after the achievement of a FI prize.

Note that rounds of type ***f*** and ***x*** are expected only for the experiment settings which involve FIs, namely the last four.

5.4 Results

We analysed the results provided by the users, focusing on five main factors: quantity of rounds submitted, quality of the results provided, agreement between users, and time needed to judge.

Figure Q3 shows the number of rounds performed by users, grouped by round and experiment setting. Note that, in the chart, we omit the rounds of type ***m*** because they are mandatory and their required number is specified by the experiment setting. As expected, the median number of rounds submitted (last block of boxes), shows appreciable differences between the ***0.1*** and ***1.1*** settings, which refer to users submitting significantly less rounds than others. Focusing only on the difference between the not gamified setting ***0.11*** and others, no evident difference was reported, apart from the ***2.11 MR*** setting which had significantly more rounds submitted than other settings. Note that ***2.11 MR*** is the only setting that included additional monetary reward. Also, focusing on the rounds of type ***f***, we see that ***2.11 MR*** is the only setting where the median number of rounds submitted is exactly 11 (meaning it was completed by at least half of users). Finally, focusing on rounds of type ***x***, we see that ***2.11 MR*** is the setting which kept the greatest number of users participating in the platform for the greatest amount of time even after the FI achievement. To answer RQ1, we can consider the use of monetary payment as the most attractive incentive to make users remain with the platform for longer.

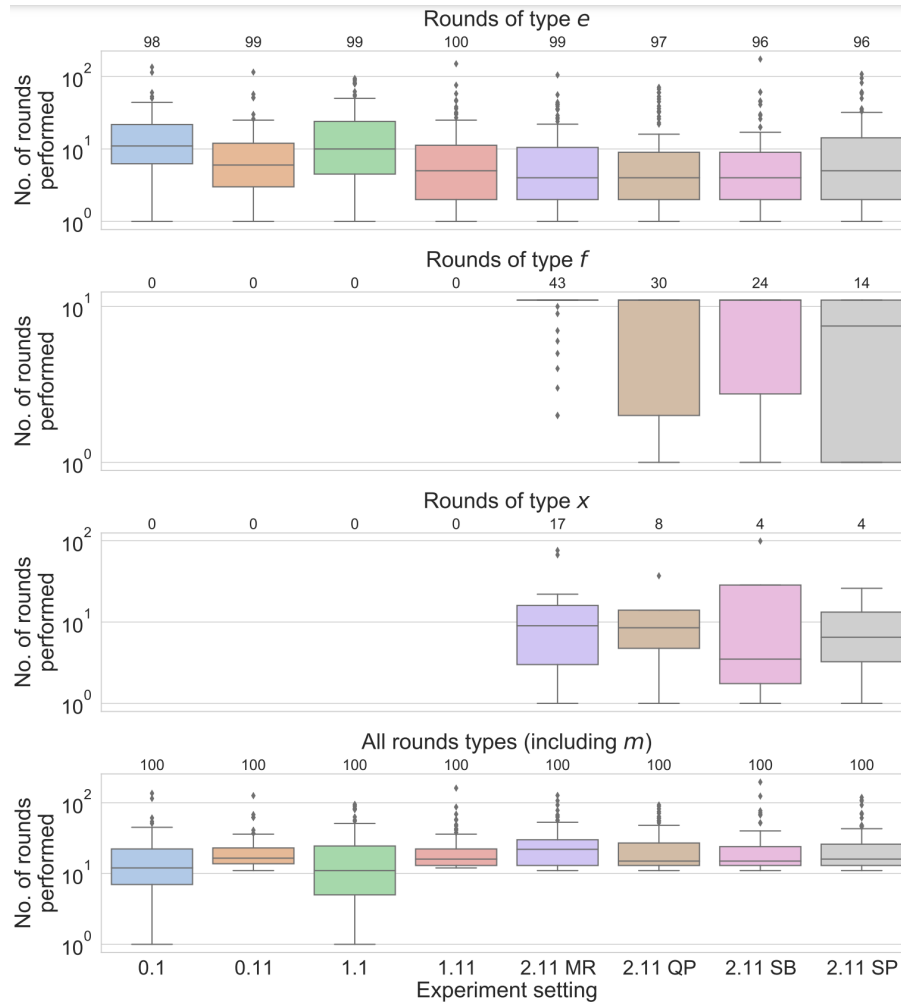


Figure Q3: Amount of rounds performed per round type, breakdown on settings.

To address RQ2, we measured round duration, meaning the time elapsed from when a user began working on a round and its completion. As done before, we plot out the data grouped by round type and experiment setting. The chart, in Figure Q4, shows that the rounds of the settings which required only one mandatory round to be performed took more time to complete than others. Nevertheless, these results could partially be affected by the learning curve that made users slower at the beginning. Moreover, looking at the settings which involved FIs, and in particular the round types affected by FIs (i.e., f and x), we can see that for 2.11 MR, QR, and SB the round duration decreased while the task progressed. Moreover, that decrease is more pronounced for MR, indicating both a long-tail effect of the learning curve and a contributor's efforts. In that regard, looking at the agreement measured with Krippendorff's alpha coefficient we notice that 2.11MR is the only experimental setting where the agreement of rounds of types f and x is lower than m and e , whereas in 2.11 QP, 2.11 SB and 2.11 SP the worker agreement increased after rounds of types m and e . This reduction in agreement combined with the reduction of round duration might strengthen the hypothesis of 2.11 MR contribution becoming faster than others, while the task progressed.

This effect was not observed for 2.11 SP, which was the FI that allowed users to see responses of others. In the future, we will investigate if this stability of round duration is due to contributors

becoming more thoughtful, doubtful or unconfident because of other people's responses (especially in presence of disagreement) mitigating the long-tail of the learning curve.

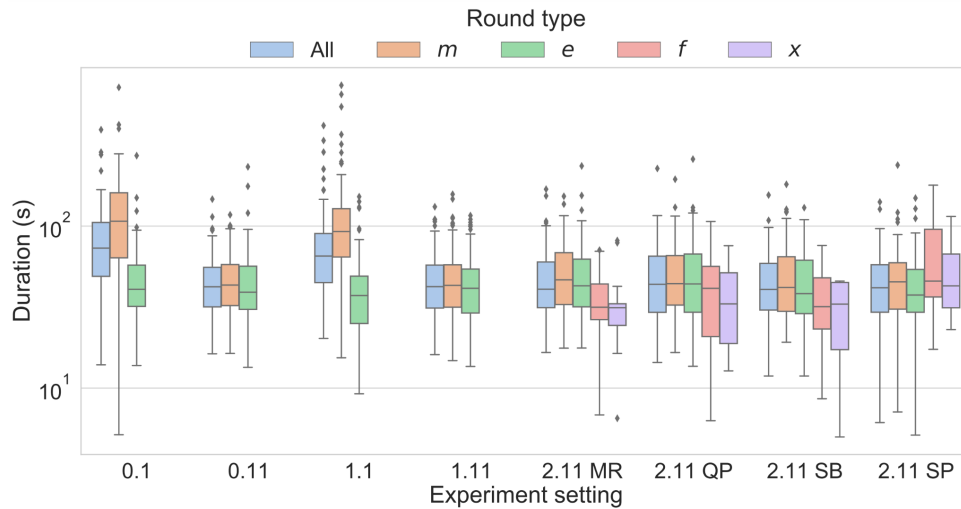


Figure Q4: Rounds duration per round type, breakdown on settings.

To address RQ3 we need to introduce the concept of quality. Thus, we compare each annotation of urban images provided by participants with the Cityscapes ground truth. This comparison returns a [0-1] quality score for each image annotated by a worker.

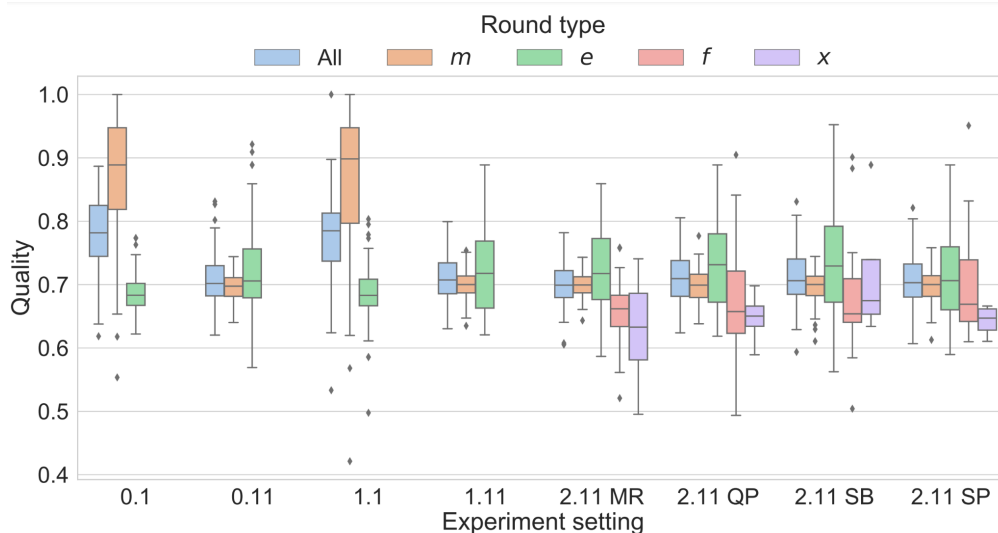


Figure Q5: Quality of the rounds submitted, breakdown on settings and round type.

The results, depicted in Figure Q5, show that the experiment settings which required only one round to judge got higher quality scores than others. Also for the x.11 settings, the *e* rounds have systematically higher quality scores than *m* ones, suggesting the quality is higher for rounds performed voluntarily. Moreover, rounds of type *f* or *x*, that are those which are affected by the presence of the FI, have lower quality than others. Combining this result with the previous, we can say that FIs allow the collection of more work, but of poorer quality. To answer RQ3, we can see in Figure Q5 how the FI that has the biggest loss in quality is 2.11MR.

5.5 Future work

For the reason written in the instruction, we conducted this experiment by recruiting contributors from Prolific. It would be interesting to repeat the same experiment using contributors from volunteer crowdsourcing projects. In fact, we know from the literature that economic incentives are the least effective way to engage collaborators. This suggests that any repetition of our experiment in a Citizen Science context would begin from a better motivated crowd, and that might have a positive impact on the results. Such repetition would not require any changes to the research questions. Nevertheless, the experimental setting should be changed, in particular by removing the fixed monetary payment.

Also, the experimental setting used values chosen empirically. E.g., we set to 11 the number of required rounds of most of the experiment settings. Nevertheless, other values could be chosen. Thus, it would be interesting to study how different experiment settings impact the results.

Finally, the task template can also vary. We opted for a task that required urban image annotation since it is quite objective (counting vehicles in a picture is usually less subjective than expressing opinions in the sentiment of a tweet) activity. We could rely on a high-quality dataset. Nevertheless, we might use other typical crowdsourcing templates, e.g., audio transcription or relevance judgement. Such a template will also change many dimensions of the task, e.g., the completion time, the task workflow and difficulty.

6 GUIDELINES

From our studies' findings, we summarise the following conclusions:

1. Motivation

- The proposed methodology for investigating the drivers of human behaviours inside communities of citizen scientists through surveys is easily reproducible and adaptable to new citizen scientists' communities.
- The proposed methodology investigates 10 variables related to altruism and intrinsic motivation, which are based on the Schwartz Theory of Basic Values. The 10 motivating factors are: *self-direction*, *stimulation*, *hedonism*, *achievement*, *power*, *conformity*, *benevolence*, *universalism*, *routine* and *belongingness*.
- The motivating factors that are more correlated with the global motivation in almost all the pilots analysed are *hedonism*, *self-direction* and *stimulation*, indicating that what mainly excites volunteers is the possibility of doing and learning something new and to contribute to a project that they are passionate about and that make them feel good about themselves.
- Low values in *conformity* and *power* in all the pilots indicate that volunteers are not at all forced to participate and they do not expect anything in return for their participation.
- The different contexts of the pilots influence the correlations between the motivating factors and the global motivation. Pilots may be different in terms of type of tasks done by volunteers (only data collection or more than one phase of the participatory science lifecycle), of level of engagement of volunteers, of geographical area (local level or worldwide as for online communities) and of importance given to data.
- Citizen science projects should adapt their approaches and tools to motivate their participants on the basis of the specific characteristics of their communities. They can likely count on a passionate and generous attitude (see high values of *hedonism*, *self-direction* and *stimulation*), while they should avoid leveraging forced participation or monetary incentives (see low values of *conformity* and *power*), but they should investigate the specific personal motivations of their target group (possibly through the adoption of our proposed survey methodology) in order to maximise the global motivation of their citizen scientists.

2. Community engagement

- Motivations in this nature conservation citizen science project were mostly collective, in line with other literature.
- Interest in volunteers' own contributions might have a place-based nature, which would mean that designing tasks that happen in a place that bears interest for the volunteer could enhance participation.
- Extensive and personalised effort in on-boarding process of volunteers may lead to increased long-term participation.

3. Contributor expectations

- Crowdsourcing contributors create their expectations based on task instructions and personal prior knowledge. Requesters should be aware of that while designing new tasks.

- Expectations are personal. The level of expectation satisfaction is personal and subjective.
- Unmet expectations might trigger uncomfortable feelings in contributors, e.g., a lack of confidence, disillusionment, frustration, a loss of interest, or suspiciousness.
- The consequence of unmet expectations can lead to different reactions and behaviour in contributors. E.g., some contributors quit the study and their results are disappointing, others are happy to try fixing the results by providing more voluntary work. Contributors' feelings drive these decisions.

4. Gamification

- Traditional gamification is not commonly used to a significant extent in microtask crowdsourcing. Moreover, our pilots show gamification can bring benefits to contributors' engagement.
- While operating in the gamified environment, contributors provide more volunteer work remaining longer on the platform.
- Furtherance incentives, gamified or monetary, might be put beside task workflow to increase engagement and prompt additional work.
- Contributors provide more work while monetary incentives are in place. Nevertheless, the quality of such work is of lower quality than when using no-monetary incentives.

8 CONCLUSIONS

This deliverable set out 4 studies conducted by ACTION partners in the context of incentives and motivation within citizen science projects. These included a motivational survey with participants from six ACTION accelerator pilots, an in-depth survey and interviews with participants from ACTION partner DBC's citizen science pilot, a study of volunteer behaviours when dealing with unexpected project results and an analysis of the effectiveness of financial and gamified furtherance incentives in crowdsourcing projects. These results demonstrate the importance of a range of *intrinsic* motivations, such as volunteers' interests. Conversely while gamified and paid incentives can drive participation, these results were generally less effective than simply allowing volunteers to participate voluntarily.

In addition to these studies, we have presented a set of guidelines synthesised from our findings. These guidelines are intended for those designing, implementing and managing citizen science projects, allowing them to maximise volunteer engagement by designing and accounting for diverse volunteer motivations. These guidelines should be considered alongside those laid out in previous deliverable 5.6.

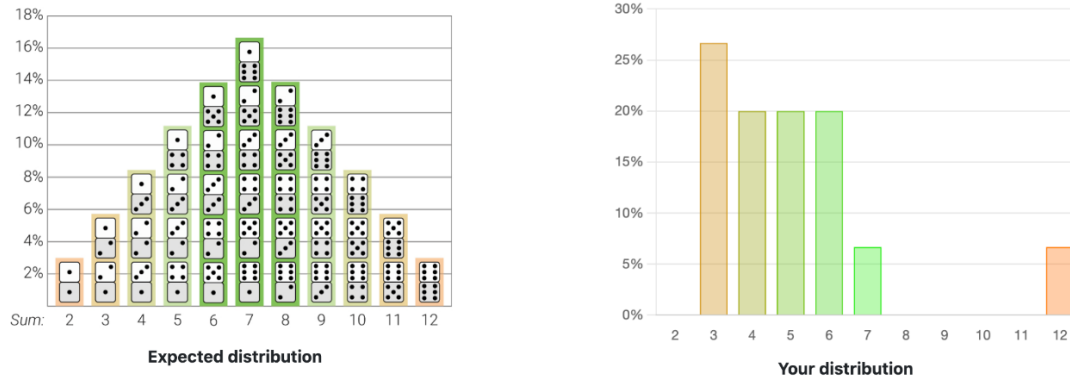
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APPENDIX



Please, answer the following three questions *about your sequence of outcomes sums*:

1. The sequence of dice outcomes is compatible with the expectations.

Completely disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Completely agree

Rate your level of agreement with a scale from "Completely disagree" to "Completely agree".

2. Why do you think you got these results? Any thoughts are welcome.

Write your explanation here

3. You reported exactly 15 outcomes as required, and that is great! Moreover, you had the chance to report more outcomes voluntarily, is there any particular reason because you stopped at 15?

Write your answer here

Please, answer the following two questions *about you*:

4. I am usually pretty accurate at predicting the outcome of a dice roll.

Completely disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Completely agree

Rate your level of agreement with a scale from "Completely disagree" to "Completely agree".

5. I should keep track of previous dice rolls so that I can figure out future outcomes.

Completely disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Completely agree

Rate your level of agreement with a scale from "Completely disagree" to "Completely agree".

Figure E6: Screenshot of the survey on motivation in presence of statistical expectations