Co-Immune: a case study on open innovation for vaccination hesitancy and access

Camille Masselot, Bastian Greshake Tzovaras, Christopher Graham, Gary Finnegan, Rathin Jeyaram, Isabelle Vitali, Thomas Landrain, Marc Santolini

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Abstract

Background: The rise of major complex public health problems, such as vaccination hesitancy and access to vaccination, requires innovative, open and transdisciplinary approaches. Yet, institutional silos, paywalls and lack of participation of non-academic citizens in the design of solutions hamper efforts to meet these challenges. Against this background, new solutions have been explored, with participatory research, citizen science, hackathon and challenge-based approaches being applied in the context of public health.

Objective: Our ambition was to develop a framework for creating citizen science and open innovation international projects that address the contemporary challenges of vaccination in France and across the globe.

Methods: We designed and implemented Co-Immune, a programme created to tackle the question of “vaccination hesitancy” and “access to vaccination” through an online and offline challenge-based open innovation approach. The programme was run on the open science platform Just One Giant Lab.

Results: Over a 6-month period, the programme mobilized 234 participants of diverse backgrounds, coordinated 8 events, involved 13 partners from the public and private sectors, and led to the creation of 22 projects, from app development and data mining to analysis and game design.

Conclusions: Co-Immune highlights that open science and open innovation approaches can be facilitated through events and online platforms. They can also help gather and coordinate non-institutional communities in a rapid, distributed and global way to address public health-related issues. Co-Immune contributes to a path for organisations and individuals to collaboratively tackle future global challenges.

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Abstract

Background: The rise of major complex public health problems, such as vaccination hesitancy and access to vaccination, requires innovative, open and transdisciplinary approaches. Yet, institutional silos and lack of participation of non-academic citizens in the design of solutions hamper efforts to meet these challenges. Against this background, new solutions have been explored, with participatory research, citizen science, hackathon and challenge-based approaches being applied in the context of public health.
Objectives: Our ambition was to develop a programme for creating citizen science and open innovation projects that address the contemporary challenges of vaccination in France and around the globe.
Methods: We designed and implemented Co-Immune, a programme created to tackle the question of vaccination hesitancy and access to vaccination through an online and offline challenge-based open innovation approach. The programme was run on the open science platform Just One Giant Lab.
Results: Over a 6-month period, the Co-Immune programme gathered 234 participants of diverse backgrounds and 13 partners from the public and private sectors and organized 8 events to facilitate the creation of 22 new projects as well as the continuation of 2 existing projects to address the issues of vaccination hesitancy and access, ranging from app development and data mining to analysis and game design. In an open framework, the projects made their data, code, and solutions publicly available.
Conclusion: Co-Immune highlights how open innovation approaches and online platforms can help to gather and coordinate non-institutional communities in a rapid, distributed and global way towards solving public health issues. Such initiatives can lead to the production and transfer of knowledge, creating novel solutions in the public health sector. The example of Co-Immune contributes to paving the way for organisations and individuals to collaboratively tackle future global challenges.

Introduction

Background

As the world faces a rise in the number of complex challenges that threaten the resilience of our economic, environmental, social and health systems we observe a shift towards more collaboration

and openness in the way science and innovation is performed [1–3], bringing closer governments, civil society, and the private sector. Examples of this include the efforts made to accelerate society's progress towards Sustainable Development Goals (SDG) [4] and the fight against pandemics such as COVID-19 [5]. Yet, access to vaccines and vaccination hesitancy remains one of the complex challenges to be addressed to achieve universal health coverage [6].

Immunization is one of the most cost-effective interventions to protect oneself and others from infectious diseases [7] saving between two million and three million lives per year [8].

Yet, the annual death toll for vaccine-preventable diseases stands at 1.5 million and large gaps in coverage persist, not only between countries but also within their territories [7]. In particular, the World Health Organization (WHO) listed vaccine hesitancy among the Top 10 Global Health Threats for 2019 [9]. Continuing global efforts to leave no one behind may be a long-standing challenge [10] when new information technologies and social media platforms are both part of the problem [11], and solution. More recently, the COVID-19 pandemic demonstrated the repertoire of logistical and administrative challenges to the deployment and administration of vaccines, especially in low resource settings [12].

In response, the WHO Global Vaccine Action Plan 2011-2020 [7] committed 140 countries and 290 organizations to promoting and prioritising greater collaboration between governments, NGOs, the private sector and all citizens to address outbreaks of vaccine-preventable diseases. Additionally, a number of new digital and open innovation initiatives have been launched: the WHO has developed the Vaccine Safety Net [13], a network of websites about vaccination; health authorities in Canada have developed a schools-based quiz to educate children about immunology and vaccines [14]; Finland is testing a computer game to communicate the benefits of HPV vaccination [15]; a project in India uses digital necklace to record children's immunization history[16], and a global Vaccination Acceptance Research Network has been established [16].

Global health guidelines showcase the positive outcomes of social participation for universal health coverage [17], which include more meaningful dialogue, more sustainable solutions and more trust from citizens in health system institutions or in the decisions that are made. Indeed, there is room for more initiatives that allow people to genuinely codesign solutions in a multidisciplinary manner during and following pandemics [18]. Hence, the number and sustainability of these types of initiatives could be amplified by fostering increased collaboration with non-academic citizens in the creation and development of solutions in an open innovation framework [19]. This is the gap that Just One Giant Lab (JOGL) is proposing to fill with the Co-Immune programme.

Research demonstrates that intensity and diversity of collaboration positively affect the quality [20] and productivity [21] of research while positively impacting the knowledge integration from participants [22]. Likewise, participant transdisciplinarity [23] seems critical to generating innovative outcomes [24] and dealing with complex real world problems [25]. Such mechanisms are often at play in the field of citizen science, promising to transform the knowledge generation landscape by tapping into networks of non-academic citizens [25, 26] in a new social contract for this kind of research [27]. Citizen science has the potential to expand the number of individuals contributing knowledge and ideas, transform how hypotheses are generated and datasets are analysed. Such approaches have already been applied to investigate individual diseases through patient-led research [28, 29] and public health challenges such as the epidemiology of cancer [30–32].

Other approaches to create and develop knowledge and solutions to complex challenges are slowly entering the mainstream. In particular, hackathons, challenge-based approaches, and the participation

of citizens in science have been flourishing over the last two decades [33], especially within the natural sciences [34] and more recently, medical sciences, public health and population-health research [35, 36].

Hackathons are short, intensive, and collaborative events that are designed to prototype solutions addressing a specific problem. They originated in the early 2000s in digital and tech fields and have been adapted to address more complex challenges in global health [37–39]. Such initiatives are not without pitfalls: they suffer, by design, from the lack of paths to sustainability for the projects they launch [40]. In response to such criticisms, there are increasing efforts, such as “Make the Breast Pump not Suck” hackathon and “Trans*H4CK”, to improve hackathon methodology by working directly with affected communities [40]. Several initiatives such as MIT collaborative design studio provide insights on hackathon methods [41] to facilitate better hackathons [42, 43]. More recently, multiple entities have engaged in organizing hackathons to address the COVID-19 crisis [44,45].

Challenge-based approaches, providing frameworks for learning while solving real-world issues, have also been on the rise in global health and proven to be efficient to generate innovative solutions and incentivize mass community engagement [44]. For example, the potential of participative models to address complex questions, and the power of contests to offer a structure that catalyses this work, has been exhibited by the “Epidemium” initiative on cancer epidemiology [45].

Despite the numerous tools and technologies created to facilitate collaboration in citizen science projects, challenges remain. These include the issue of the complementarity, coherence and diffusion of these initiatives [33] to efficiently address international policies and local needs, as often the local adoption of hackathon solutions remains low [46].

The promotion of transdisciplinarity and citizen science in an open innovation framework, coupled with methods such as hackathons and a challenge-based approach therefore represent an opportunity to address current complex challenges of vaccination, that would overcome the limits of either solution alone. In this article, we describe the design, implementation, and outputs of “Co-Immune”, a collaborative open innovation programme run in 2019 to address vaccination hesitancy and access to vaccination.

Objectives

Co-Immune’s ambition was to develop an environment that favors the creation and development of citizen science and open innovation projects addressing the contemporary challenges of vaccination in France and around the globe. This programme had four specific objectives: (a) to foster a collaborative, open and transdisciplinary dynamic (b) to promote the emergence of accessible knowledge and innovative solutions (c) to support participants in the elaboration and development of their project and (d) to disseminate the outputs and results in an open science framework. In this study, we describe the methodology of Co-Immune, its implementation and present its key outcomes.

Methods

Design

The overall programme duration was 10 months (March 2019 to January 2020), divided into 6 months of preparation and 4 months of roll-out of activities that included offline and online events, support for the development of citizen science projects, and assessment and awards for projects participating in the challenge-based competition. The main output of the programme were projects, categorized as leading to a) knowledge production, if they performed data analysis or generated new knowledge whether it is specific to context or generic [47]; and/or b) knowledge “transfer” [48], and/

or solutions such as hardware, software, and interventions.

Co-Immune was coordinated online through the platform of JOGL (app.jogl.io) and supported by 13 partners from the public and private sector (Supplementary Table 1). The challenge-based nature of the programme was designed to be an incentive for teams and participants to continue developing their projects after hackathon events or create their project on JOGL at any other time.

The governance of Co-Immune was designed to provide freedom for projects to develop innovative solutions while ensuring their compliance with local and international regulations and consideration of ethical and scientific integrity. To this end, we constituted an independent Committee for Ethics, Science and Impact (CESI), which issued an opinion on the rules of participation in the programme and validated the strategic orientation of the programme. Public health priorities were identified based on a literature review and divided between two main challenges to streamline participants' work: vaccination coverage, and vaccination hesitancy. They were then validated by the CESI. In addition, through a series of semi-structured interviews, experts at the 7th Fondation Merieux Vaccine Acceptance conference [49] identified eight specific issues to address and potential room for solutions. The CESI also participated in the co-elaboration of the assessment grid, used as a base to grant non-monetary prizes to projects in December 2019.

To be eligible for a prize, a project was required to have created a comprehensive description of their initiative on the JOGL platform and a video pitch. This material was provided to experts in charge of the assessment.

Participant recruitment

Participants were recruited through our network of partners from around the globe and social media communication. Participation was open to everyone above the age of 18, if they agreed to follow the participation rules validated by the CESI. Participants could take the role of "project leaders" and "contributors".

Just One Giant Lab (JOGL) platform

Co-Immune participants used the JOGL platform to document their projects and recruit collaborators throughout the course of the programme. JOGL is a decentralized mobilization platform designed for use in collaborative research and innovation (Figure 1). Within JOGL platform users can create a profile and declare their skills. Once registered, they can create or join projects, follow the activity of other members, post on their project feed and comment on other posts. They can also highlight needs for a project they are part of, specifying skills that can help to solve them. We compared the JOGL features to other online platforms for citizen science, social networking and science/publishing through a cluster analysis (Figure 1 & Supplementary information), indicating it is functionally similar to other platforms in the space and is suitable to hold a citizen science programme such as Co-Immune.

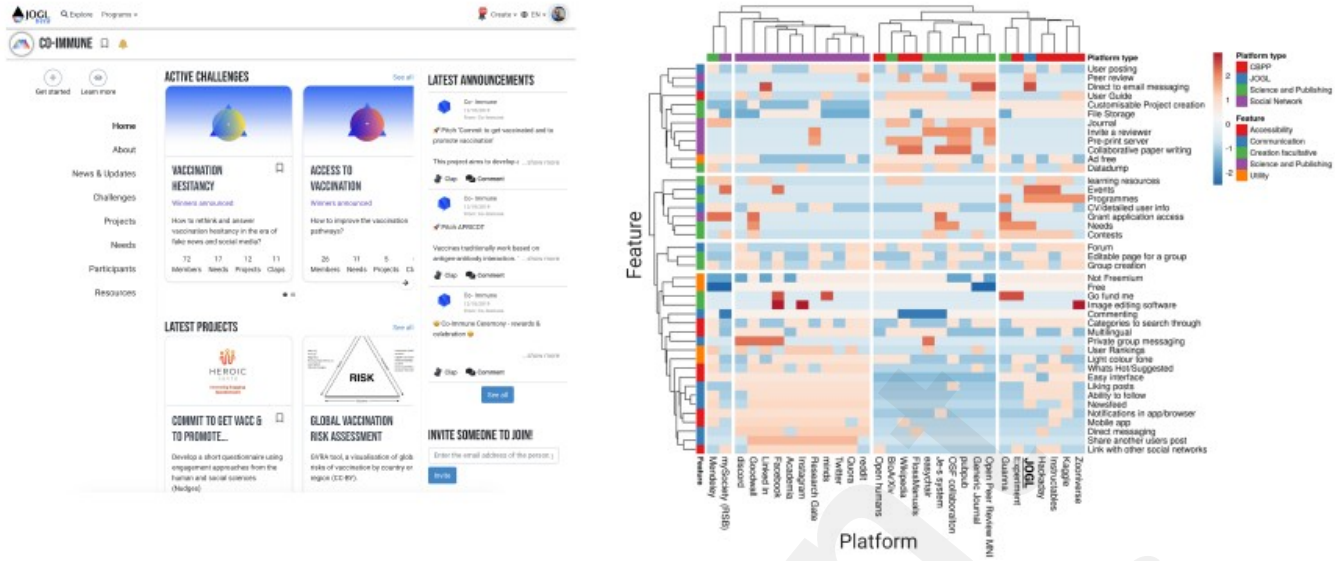

Figure 1. Overview of the JOGL platform. (left) Screenshot of the JOGL platform (app.jogl.io) and (right) heatmap of feature presence across popular online tools. For each platform (columns), we numerically encode the presence (1) or absence (0) of each feature (rows). We then compute for each element a Z-score by standardizing values across platforms, represented here by the color spectrum: blue-low to red-high. CBPP- Citizen based peer production network/citizen science platforms.

Implementation

The Co-Immune programme was realised through an interrelated and interacting set of technological and social features (see Figure 2). Our coordination team implemented the larger programme (events, online platform, contest approach) and helped to recruit a community of partners and participants which interacted with each other and were supported in their efforts through the high-level design features. With support of the governance structure of the Co-Immune programme the individual projects managed to provide outputs that included knowledge production and transfer, and solutions such as hardware, software, and interventions.

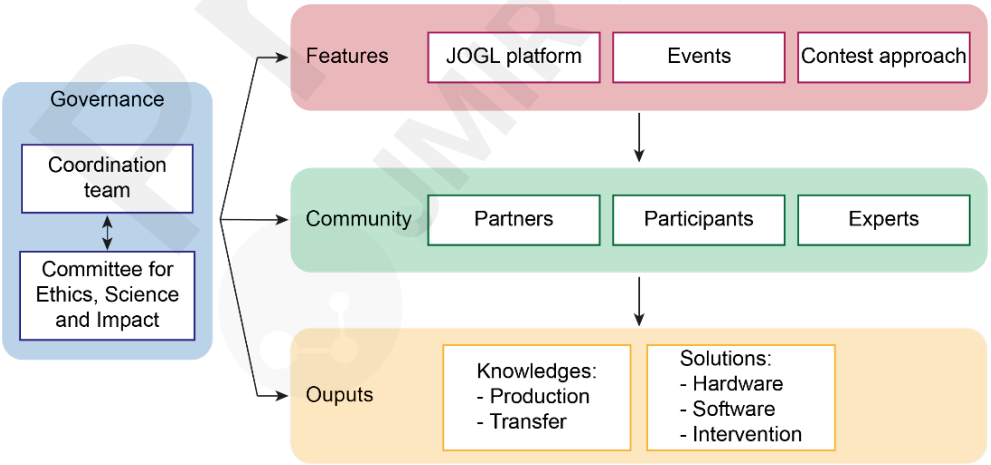

Figure 2. Workflow of the Co-Immune programme design.

Building an open community

To build the community, we contacted organisations involved in a wide range of domains before the launch of the programme, creating a first pool of contributing professionals and students. We also recruited participants via the organization of events, typically in the evening, aimed at creating projects, fostering collaboration among participants to address project needs, and provide

mentorship. To facilitate the coordination of the community, all participants were required to use the JOGL platform to describe their projects, form teams, list their needs and initiate collaboration.

In order to create a supportive and collaborative environment for the participants, we reached out to a wide range of organisations to establish partnerships. Our intention was twofold: i) facilitating the participation of their students and employees as participants or mentors by involving their institution, ii) enhancing the sustainability of projects after the course of the programme by connecting them with potential partners at their early stage of development.

The 13 partners operated in the health, technology, and social sectors, and included research, innovation, and education organizations, as well as professional networks, incubators, and communication specialists (see Figure 3). The number of partners grew over the lifespan of the initiative and were often suggested by existing partners or through connections made during events.

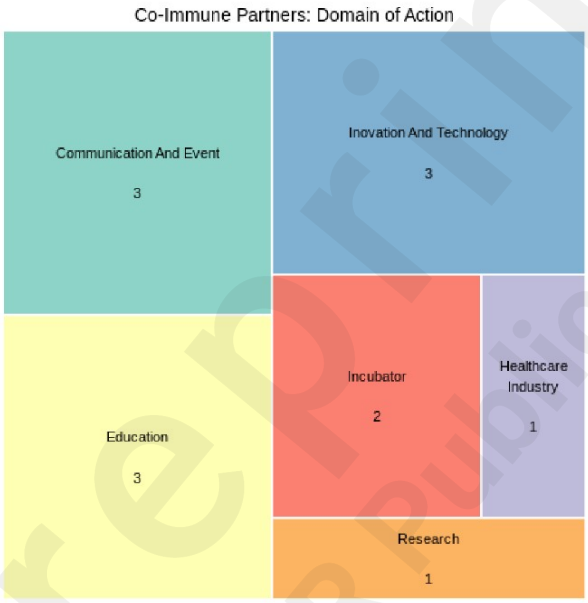

Figure 3. Treemap representing the domains of action of the 13 Co-Immune partners.

We organized 8 offline and online events between October and December 2019 (Table 1). Participants for events were recruited through social media and mailing lists leveraging our network of partners. Among the four onsite events that were organized, two were hackathons aimed at motivating participants to join the programme, while the other two were aimed at fostering collaboration around the most advanced projects. Their median duration was 3 hours.

The facilitation of the hackathon-style events relied on the use of participatory and collective intelligence design and problem-solving techniques[50]. In particular, participants were encouraged to form multidisciplinary teams including both professionals and students.

Table 1. Co-Immune events

Name	Mode Type Location	Duration (hours)	Objective	Design Supporting partners	Number of participants
Launch	Offline Ceremony CRI, Paris	3	Gather the initial community	Presentation of the programme design, features, timeline and partners, networking.	60
OpenJOGL "Co-Immune"	Online	1	Q&A session on the programme	Presentation of Co-Immune, questions and answers.	3
Sprint "Open Data"	Offline Hackathon CRI, Paris	2.5	Build community, create projects, create data repositories	Statement of the problem (videos of experts), team formation and effort, mentoring, publication of results on the JOGL platform. Supported by: CRI, CorrelAid,	25
OpenJOGL "Vaccination awareness escape game"	Online	1	Foster collaboration around single project	Pitch of the project and its needs, feedback from experts, questions and answers.	7
Sprint "Project creation"	Offline Hackathon CRI, Paris	4	Build community, create multidisc. projects	Statement of the problem (videos of experts), ice breaker and multidisciplinary team formation and effort, mentoring, presentation of results and vote for the most promising projects, publication of results on the JOGL platform, networking. Supported by: CRI, Epitech, Wild code school, CorrelAid, Excelya	22
Sprint "Open Data"	Offline Hackathon Wild code school, Paris	3	Accelerate the development of projects related to data science	Selection of a project by participants among the 2 choices available, team formation and effort, mentoring, presentation of results and publication on the JOGL platform, networking. Supported by: Wild code school, CorrelAid, Excelya	15
Sprint "Open Data"	Offline Hackathon Epitech, Paris	3	Build the community, create projects, accelerate the development of one project using twitter data	Statement of the problem, selection of a project by participants among the 4 choices available including one already existing project, team formation and effort, mentoring, presentation of results, vote for the most promising project, publication of results on the JOGL platform, networking. Supported by: Epitech, Kapcode, Excelya, Correlaid	35
OpenJOGL "HERA - a mobile health platform to improve refugees' health"	Online	1	Foster collaboration around single project	Pitch of the project and its needs, feedback from experts, questions and answers.	7
OpenJOGL "Better documentation for better collaboration"	Online	1	Help teams documenting their project in the most open and reproducible way	Expert presentation on best practices for documenting open science projects, presentation of Co-Immune expectations for documentation, questions and answers.	13
Closing ceremony	Offline Ceremony CRI, Paris	2	Close the Co-Immune programme	Presentation of the main outputs of the programme, reward of the best projects.	70

Three partners in Paris – Epitech, the Wild code school and the Center for Research and Interdisciplinarity (CRI) – co-organized and hosted events for their students respectively in their engineering, coding, and life science and education schools. Other partners – such as Kapcode, Excelya, and CorrelAid – mobilized their teams to act as mentors during these events. A total of 14 mentors attended events, five came to more than one event.

In addition, we organised four one-hour online events. The first was an opportunity to share information about Co-Immune with people around the globe. Another event discussed best practices to document open-science projects. Finally, two events focused on the resolution of needs of single projects (Table 1).

Co-Immune experts: CESI members, mentors, interviewees

We considered "expert" all the members of the CESI and experienced professionals of a certain field who attended events and provided technical guidance to teams as "mentors".

The CESI members were sought to represent the diversity of stakeholders involved in advancing

access to vaccines and reducing vaccine hesitancy. By choosing interviewees who were researchers specializing in the challenges of access to vaccines and vaccination hesitancy, we aimed at benefiting from their expert understanding of the issue and of the priorities to be addressed to streamline the work of participants around particular problems. Finally, we grew the pool of mentors over the span of the programme to best match their expertise with the needs of the projects in an agile manner.

Overall, their domain of expertise ranged from biology, to social sciences, design, technology and data science (Figure 4). A third of them were working as health or public health professionals.

The CESI counted 8 volunteer members and included virologists, pharmacists, health economists, experts in the digital and ethics field and biologists, working at international, national and local levels of the health system. All of them worked for public or nonprofit organisations.
Interviewees were mostly researchers in social sciences and medical practitioners.

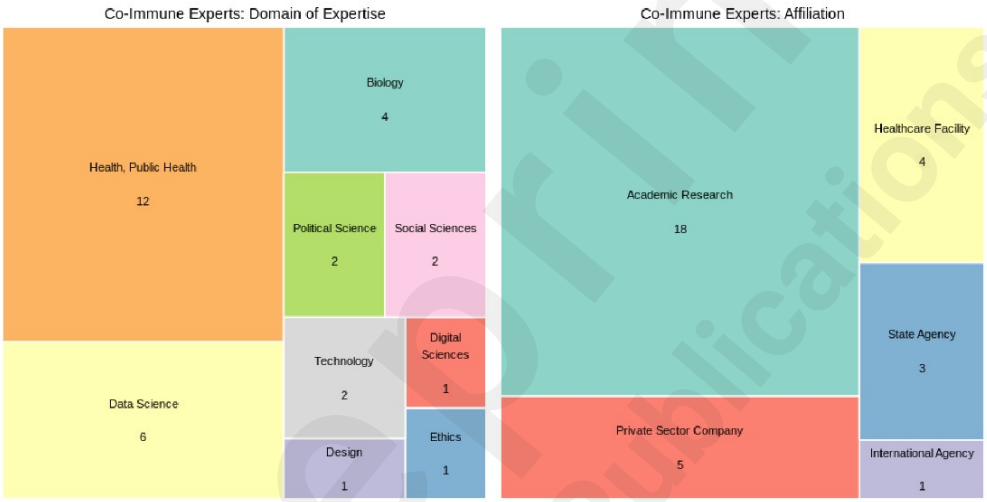

Figure 4. Treemap of the 31 Co-Immune experts: (left) domains of expertise and (right) affiliations.

Co-Immune projects assessment

The assessment of projects by experts was designed to be an opportunity for learning and growth. To be assessed, teams were asked to provide a video pitch summarizing their project and a detailed documentation on their project page on the JOGL platform, including links to their open access data and code. Project assessment was performed through a grid co-developed by JOGL and the CESI. In addition to grades, teams received detailed feedback on their project.

The assessment grid was based on a literature review of project evaluation standards and consisted of 10 questions graded from 0 to 5 (Supplementary Table 2). Three areas were assessed: the approach, the implementation strategy, and the impact. First, the assessment of the approach included: i) Clarity and relevance of the problem and alignment with the programme scope ii) Fit between approach/methodology and problem statement iii) Innovation potential: the project introduces ground-breaking objectives, novel concepts or approaches. Second, the implementation strategy was assessed following the criteria: i) State of progress towards set goal (state of advancement); ii) Clarity and relevance of the timeline and needs for future (major tasks, milestones); iii) Project actively engages and aligns with all relevant stakeholders. Finally, the assessment of the impact covered: i) Clarity and relevance of the criteria used to measure impact; ii) To what extent does the project considers its ecosystem (ecological, environmental, ethical and social considerations); iii) Sustainability and scalability of the project in the long term; iv) Open and reproducible dissemination

strategy. For each of these 3 categories, JOGL awarded a prize to the project with the best score based on the grades given by reviewers. Additionally, a Grand Prize was given to the project with the overall highest score. JOGL provided visibility while two partners also provided rewards to a project of their choosing.

JOGL platform data collection and analysis

Participants gave their professional background, their skills and employment status on JOGL. This data was used to evaluate the composition of the community. All users who joined JOGL during the span of the programme were considered to be participant of Co-Immune, as it was the only ongoing programme and all outreach activities were related to it.

To better understand how skills were related across participants, we used a network approach to assess similarity between skills and get further insights about the global diversity of the community. In this network approach, each declared skill is a node and the considered skills as linked if they co-occur in a participant. Links are then weighted by the number of participants they co-occur in. Gephi 0.9.2 was used to represent the network in Figure 5, and its modularity algorithm was used with default parameters to compute communities.

We provide the data related to this study on Zenedo [51]. This data includes a) link, description, and assessment scores of projects b) profile of platform users c) description of events d) profile of experts e) list and type of partners.

Results

Community growth through events

During the programme, 234 participants signed up to the platform (Figure 5). The participant growth was mostly linear over the lifespan of the programme (2019-07-10 to 2019-12-18), suggestive of a potential for continued growth if the programme had continued. The growth rate outside of events, at around 1 per day (between 0.86 - 0.98 users/day), is consistent with the pre-kickoff growth rate (0.94 users/day). This highlights the importance of events (dashed lines in Figure 5) for driving participant enrolment, with the 4 offline events accounting for 45% of the growth. In total, offline events were responsible for the generation of 82% (18/22) of projects. The rest consists of four projects created on the platform outside of events and two already existing prior to the programme.

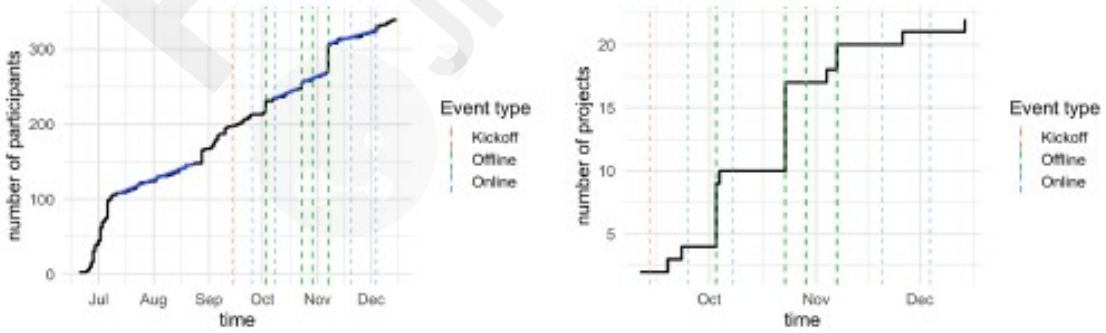

Figure 5. (left) Growth of the number of participants and (right) number of projects over the lifespan of the programme. Dashed bars show when events for community facilitation where held (green: offline events, blue: online events, red: kickoff meeting). Blue lines give a linear fit during the corresponding periods, showing stable growth pre- and post-kickoff.

Participant skills and backgrounds: a transdisciplinary community

Out of the 234 participants, 187 declared their job category. The community was composed of a mix of students (67/187, 36%) and workers (94/187, 50%), most of whom were full time (86%) (Figure

6). Other categories included ‘between jobs’ (1), ‘non-profit’ (12) and ‘for profit’ (3). While 60% of the participants were based in Paris, approximately 40% of all enrolled participants came from regions including the rest of Europe, the Americas, Africa & Asia.

The 234 participants specified a total of 492 unique skills (median 3 skills per participant). We observe a high representation of data science and coding alongside biology, which altogether relate to the technical skills emphasized during the programme (Figure 6). The skill network shows that the community spans a vast interdisciplinary landscape: from open science to open data and coding, and from project management to biology. The network exhibits a giant component of 416 interconnected skills (84% of all skills) (Figure 7). This giant component was in turn analysed for topological modules using modularity maximisation (see Methods). Modularity maximization resulted in the identification of 12 modules corresponding to sets of skills that tend to co-occur more than with other skills. Since these skills are linked through the participants who share them, they can be understood as “participant types" constitutive of the Co-Immune community.

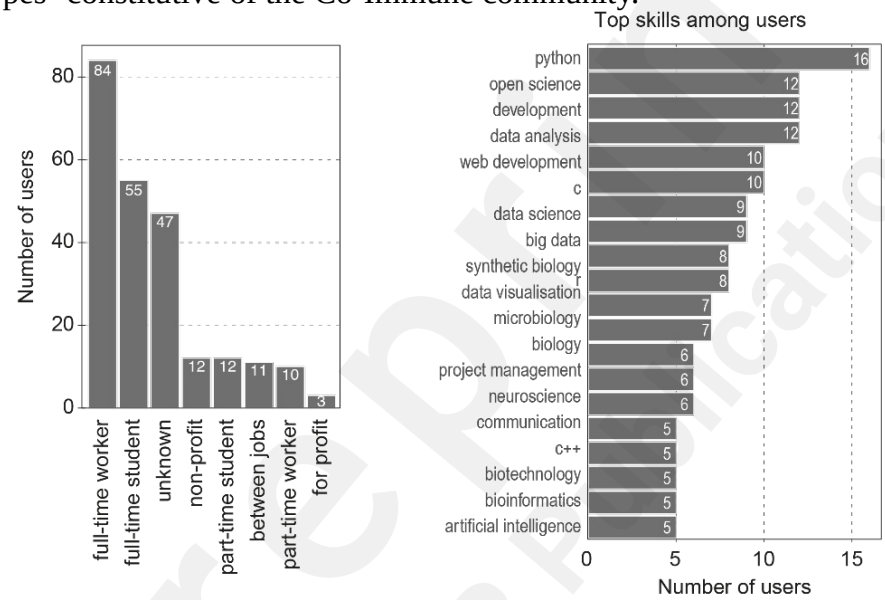

Figure 6. An overview over the Co-Immune community: (left) participants category and (right) the 20 most represented skills in the Co-Immune community.

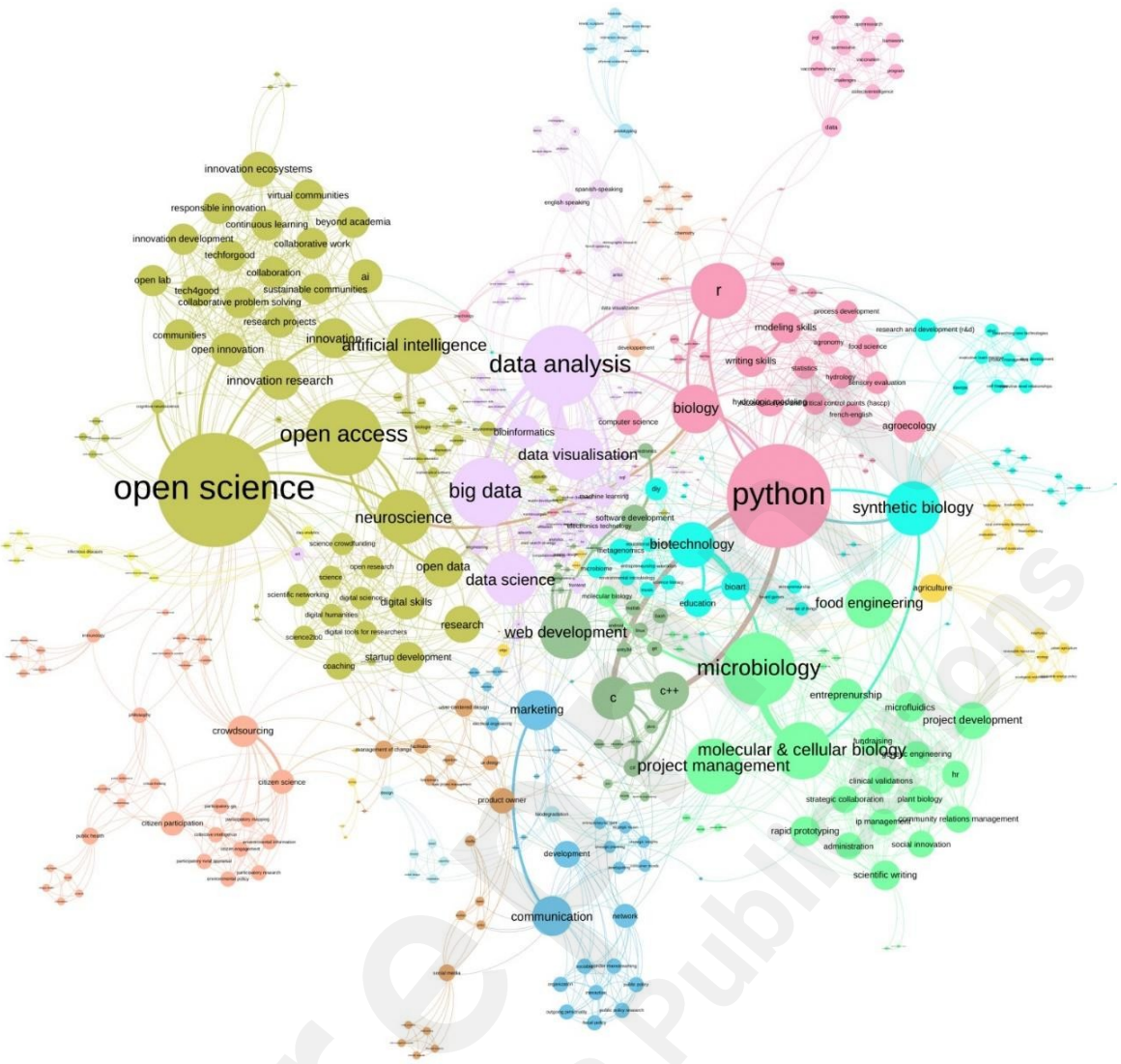

Figure 7. Skill map of the Co-Immune community. Skills are linked if they appear in the profile of the same participant. Link weight indicates the number of participants sharing the skills. Node size indicates weighted degree.

Co-Immune projects description

Table 2. Co-Immune project description

Project name	Project status	Solution category	Summary description
HERA: a mobile health platform to improve refugees' health	Assessed[a] Awarded Grand Prize Best approach prize Best impact strategy prize	Software Knowledge transfer	Mobile health app designed for improving the monitoring of vaccination and perinatal health of Syrian refugees in Turkey. It provides recall of vaccines, storage of health data, health promotion (educational content), financial incentives for immunization.
Qualitative analysis of Tweets on Vaccination	Assessed Awarded Partner prize	Software Knowledge production	Web based platform providing real time visualisation and analysis of tweets related to vaccination and vaccination hesitancy. Data analysis included sentiment analysis and network analysis. An area of development was the development of predictive models of epidemic occurrence based on twitter data.

HEROIC Santé - Commit to get vaccinated and to promote vaccination	Assessed Awarded Best implementation strategy prize	Intervention Knowledge transfer	A short questionnaire (7 minutes) using engagement approaches from the human and social sciences, such as “the importance of the source,” “voluntary consent,” or “fear and danger management,” to engage healthcare professionals and users not only to be vaccinated against the flu, but also to promote flu vaccination.
Project APRICOT	Assessed Awarded Partner prize	Hardware	Development of a synthetic biology-based methodology which addresses the evasion mechanisms adopted by the mycobacterium tuberculosis and induce the acceleration of lysosomal biogenesis improve antigen presentation.
Vaccination Awareness Escape Game	Assessed Not awarded	Intervention Knowledge transfer	Escape Game to raise vaccination awareness among the general population.
Harmonize Vaccination	Assessed Not awarded	Software Knowledge production	Tool for parsing various formats of vaccination coverage data sets and to visualize them on a common platform.
Pass it on: A game about vaccine hesitancy	Assessed Not awarded	Software Knowledge transfer	Role-play video game aiming to improve the capacity of health professionals to respond to their patient's hesitation to be vaccinated.
Global Vaccination Risk Assessment	Assessed Not awarded	Software Knowledge production	A tool to create an overview of risk factors of “not getting vaccinated” by country while looking at the more comprehensive picture. The methodology of this project is based on Fuzzy Logic, multi-criterion analysis, and risk triangle.
Immuno	Not assessed[b]	Hardware Knowledge transfer	Board game providing access to the general public's understanding of medical sciences related to immunisation
Vaccine DataDump	Not assessed	Software Knowledge production	Vaccination related data repository and analysis tool for quick analysis of vaccine related issues.
Measuring vaccination hesitancy from social media	Not assessed	Software Knowledge production	Data analysis of social media (Twitter) to examine if negative sentiment related to vaccination precedes declaration of symptoms and study the relation between vaccination hesitancy and epidemiological outbreaks.
Mortality according to access to vaccines	Not assessed	Software Knowledge production	Data analysis exploring the link between immunisation coverage, mortality rate and distance from health centers.
The health system matrices	Not assessed	Software Knowledge production	Exploratory analysis of the various parameters influencing vaccination coverage over time.

Meta immune - Data exploration of existing DB	Not assessed	Software Knowledge production	Data lake on immunization data.
Biloba (projet tiré de)	Not assessed	Intervention	Intervention incentivising people to increase vaccine uptake through vouchers, supporting the existing mobile App Biloba.
Wakuchin Senshi	Not assessed	Intervention Knowledge transfer	An interactive role play board game to increase the awareness about vaccination among general population
Neutralizing information about vaccines	Not assessed	Software Knowledge transfer	Algorithm parsing web pages, identifying misinformation and trustful content to help users in their health decisions related to vaccines. This also aims to be used by search engines in their recommender systems.
Go Viral !	Not assessed	Intervention Knowledge transfer	Communication campaign on social media using gamification methods to illustrate contagion among users and thereby increase the awareness of the importance of vaccines.
Make Vaccines Affordable	Not assessed	Software Knowledge transfer	A web based portal with data related to population demand for care in order to negotiate prices of vaccines with suppliers.
Analyse de tweets liés à la vaccination	Not assessed	Software Knowledge production	An analysis of discussion in vaccination related posts on Twitter and their evolution over time.
Detect vaccine administration in social media patient data	Not assessed	Software Knowledge production	A classifier able to detect vaccine administration in tweets related to vaccination
Detect vaccine hesitancy in social media patient data	Not assessed	Software Knowledge production	A classifier able to detect vaccine hesitancy in tweets related to vaccination

a: projects which were assessed by experts at the end of the programme. To be assessed by a pool of experts, the project team needed to provide a detailed documentation of their project, a short video pitch, and deposit their data and code on the JOGL platform.
b: projects which were not assessed by experts at the end of the programme. Projects that did not provide sufficient documentation were not assessed.

A total of 22 projects were created by 20 project leads, with teams of up to 11 members (Table 2). Among these, 15 projects proposed to develop software covering web technologies, mobile apps, algorithms, data lakes, data modeling, analysis and visualisation tools. The 7 other projects included hardware development and interventions involving biotechnologies, game design, behavioral sciences, education and communication. Overall, a third of the projects focused on knowledge transfer.

Among the 15-project relying on software technology, 11 projects aimed at contributing to the production of knowledge by facilitating the analysis of publicly available data via the use of parsing tools and the creation of repositories (N=2), the analysis of open data (N=3), the development of machine learning tools to extract and analyse Twitter data related to vaccination hesitancy (N=2), and

the production of data visualizations (N=3). In particular, more than 40 datasets were identified and collected by 4 projects created during the data-centered events. In addition, a database of 2,464 tweets (in French) posted over a period of 7 years was made available by a partner and another dataset of 89,979 tweets was gathered by the project 'Live Twitter Data analysis and visualization on Vaccination'.

Four projects used software for knowledge transfer: For instance, the HERA project provided educational content and health data storage through their mobile app to improve the monitoring of vaccination and perinatal health among Syrian refugees in Turkey. The "Pass it on" project focused on role-playing video games directed to health professionals as another method of knowledge transfer. The "Neutralizing information about vaccines" project implemented an algorithm for parsing web pages, helping citizens identify trustworthy content related to vaccines.

A total of 5 projects focused on different interventions, including raising awareness about vaccination through an escape game (Table 2, "Vaccination Awareness escape Game"); communication campaigns on social media (Table 2, "Go viral!"). The "Heroic Santé" project developed and tested a short questionnaire using engagement approaches from social sciences to engage healthcare professionals and users around the question of flu vaccination (Table 2, "Heroic Santé"). Finally, one team proposed to apply synthetic-biology methods to tuberculosis vaccines (Table 2, "project APRICOT").

Co-Immune projects assessment

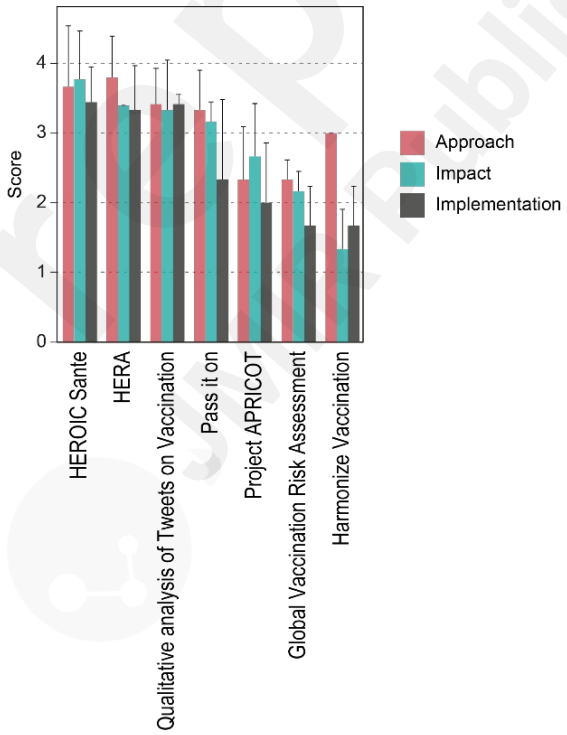

Figure 8. Barplot of review scores per category for all reviewed projects. Bars show average value for all questions related to each category, and error bars represent standard deviation. Projects are shown by decreasing global score.

Seven projects provided sufficient documentation on JOGL to be assessed by the pool of independent experts. In total, 27 reviews were performed, yielding scores ranging from 18 to 32.8 out of a possible total of 45 across the different dimensions that were assessed (approach, implementation strategy, and impact). The average score was 25.1 (+/- 6.4).

"HERA: a mobile health platform to improve refugees' health" was awarded with prizes for best approach (mean score of 11.4/15) and impact (mean score of 14.6/15). "HEROIC Santé - Commit to get vaccinated and to promote vaccination" was awarded the best implementation strategy prize (mean score of 10.33/15).

The projects were globally more successful in terms of approach with an average score of 9.37 out of 15 points (+/- 1.79 Stdev). Four projects (Figure 8) had a score higher than 4/5 for the clarity, relevance, and alignment of their problem statement with the programme objectives. For 6 projects the fit between the methods and the projects' objectives was scored highly by reviewers, with a score of at least 3/5.

The implementation strategy score of projects was overall low given the early stage of the projects at reviewing time. As such, only projects existing prior to the program - "HERA" and "HEROIC Santé", got a score of at least 3/5.

JOGL awarded winners for each category a physical space for showcasing their project during the 2020 ChangeNow forum in the Grand Palais in Paris, and tickets for MaddyKeynote – a major innovation event in Paris. Two partners - Excelya and the Wild Code School, also provided rewards to the project of their choice. Additionally, the "Qualitative analysis of Tweets on Vaccination" was awarded to be the focus of a hackathon by the Wild Code School, and the project "APRICOT" was offered technical support for data science, legal and regulatory affairs by Excelya.

Discussion

The Co-Immune programme was designed to foster the creation and development of citizen science and open innovation projects addressing the contemporary challenges of vaccination in France and around the globe by reaching four specific objectives: (a) to foster a collaborative, open, and transdisciplinary dynamics (b) to promote the emergence of accessible knowledge and innovative solutions (c) to support participants in the elaboration and development of their projects and (d) to disseminate the outputs and results in an open science framework. Below we discuss to what extent Co-Immune reached these objectives and highlight the challenges and facilitators in implementing such a programme.

First, the programme succeeded in creating a collaborative and transdisciplinary environment through its three core features: the JOGL platform, the organisation of events, and the contest approach. This led to forming partnerships with 13 different organizations and recruiting over 230 participants who displayed 492 unique skills and got engaged in creating 22 projects. The use of on-site hackathons was beneficial in gathering non-academic participants from various backgrounds. Our data shows that in-person events and local outreach played a significant role in growing the community around Co-Immune. These offline events recruited 45% of the total community. Local enrolment was further strengthened by local partnerships, such as higher education organisations. However, the localization of our on-site events in Paris could not allow for the participation of people living in other parts of France or the rest of the world. Additionally, our online communication restricted the access of the online events to our realm of influence, and to people with an internet connection. A more inclusive participation geared towards people with diverse socio-economic status and geographic situations is desirable in the future to give them agency over solving the problems they are affected by. The development of new communities is usually a slow process in the absence of exogenous shocks such as the surge in collaborative communities created by the COVID-19 pandemic [52]. Tapping into existing projects and networks for events has proven to be fruitful in our case, allowing for a steady growth of the Co-Immune community up until the end of

the programme. However, we did not observe further growth of the community after the end of the programme. This highlights that in order to build a sustainable community using open innovation to tackle global health challenges, one needs to facilitate the entry and exit of members, provide resources to support the current ones, focus on building on existing communities and projects, design inclusive environments for collaboration, and empower members to run their own activities.

Second, two design elements of the programme converged to promote the emergence of knowledge and solutions to address aspects of access to vaccines and vaccination hesitancy: the identification of challenges by experts of the field, the alignment of the programme strategy with national and international policies by frequent consultation of public health bodies and mobilization of members of public institutions in its Committee for Ethics, Science and Impact. Yet, greater representation of people affected by poor access to vaccines and people who are hesitant would be desirable to strengthen the alignment between the solutions developed and the most pressing needs at the local level.

Recently, online events have been used widely during the COVID19 pandemic [52–54], supporting our initial assumption that forming and animating a distributed online community for public health programmes is a relevant approach.

Third, the use of the JOGL platform, the mentorship during events, the assessment and feedback from experts, and the connection with a wide range of partners supported participants in the elaboration of their project in a punctual way. The use of the JOGL platform enabled projects to gain visibility, list their needs to create interfaces for collaboration, and share open datasets, code and tools. Indeed, online platforms can offer projects that started at hackathons a pathway to pursue their development, potentially alleviating one of the main drawbacks of such short temporal interventions [42]. In this case, it also enabled the programme coordinators to connect participants with project leaders based on a match between needs and skills. Yet, this approach was time-consuming, and scaling up our efforts proved to be challenging. The automation of such matchmaking tasks through a recommender system would help to minimize these efforts and increase the impact of projects through accelerated development [55]. In addition, mentoring is a known strategy that is used by open, online communities [56, 57] and was leveraged by the Co-Immune programme. Given the diversity of backgrounds and level of expertise across the participants, it was necessary to engage a similar diversity within the mentors. In our context, the highly-rated projects which were eventually awarded did not originate or participate in hackathons, but rather benefited from Co-Immune as a platform for further growth. Several of these projects already existed before the start of Co-Immune and had a higher maturity level than the projects created during the short span of the programme. In addition, these projects were launched and run by people outside the larger Paris region. We thus stress the potential of online platforms and open innovation to build on existing projects, replicate, adapt and scale their activities in other contexts. Additional support consisted in promoting visibility on social media by the organisation team, and opportunities for networking during events. Although no financial compensation was provided as part of this programme, partners, through their own experts and co-organizing events, engaged in close relationships with JOGL and the individual projects. This was favorable to sustain collaborations and projects after the end of the programme. In the future, the sustainability of the newly created project efforts could potentially be improved using incentives such as microgrants or fellowship programmes for continuing projects in the post-programme period [55]. While the short time frame and limited resources allocated to the programme didn't allow us to implement a strong monitoring and evaluation strategy, future implementations should ensure that they conduct a minimum of pre-post programme data collection for assessing the full impact of the programme.

Finally, the open science environment of this programme was not only an asset to disseminate the outputs and results of the projects developed, but it also enabled them to replicate initiatives and thereby accelerate the resolution of the global health challenges they address. An example of this is given by the team of the project “HERA: a mobile health platform to improve refugees’ health” who opened its code, enabling any individual to replicate it. However, the lack of a thorough evaluation strategy prevents us from reaching a more definitive conclusion on the effective replication of projects carried out in Co-Immune,

Co-Immune showcases that short, focused programs can be efficient at mobilizing diverse communities in a rapid manner and harvesting ideas from various domains to address global health challenges. Yet, more case studies and evaluation work on similar programmes are necessary to assess the full relevance of their design and the impact of the projects that are developed within them.

Conclusion

Co-Immune highlights how open innovation approaches and online platforms can help to gather and coordinate non-institutional communities in a rapid, distributed and global way towards solving SDG-related issues. The Co-Immune programme gathered participants and partners from various backgrounds in a newly formed community to facilitate the creation of new projects as well as the continuation of existing projects to address the issues of vaccination hesitancy and access. In an open framework, the projects made their data, code, and solutions publicly available.

Through the ideas of hackathons and other contest approaches, such initiatives can lead to the production and transfer of knowledge, creating novel solutions in the public health sector. The example of Co-Immune contributes to paving the way for organisations and individuals to collaboratively tackle future global challenges.

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Authors contributions

TEL and IV co-designed at the early stage of the initiative the thematic and the scope of the programme. CMM and TEL conceived the programme. CMM led the coordination team of the programme. CMM, BGT, TEL, CLBG and MS participated in the programme implementation. BGT, RJ, and MS analysed data and CMM, BGT, GF, CLBG, MS wrote the paper.

Competing Interest Statement

All authors have completed the ICMJE uniform disclosure form. No support from any organisation during the elaboration and submission work of this manuscript; Just One Giant Lab received funding from Sanofi to develop and implement the programme which include publication fees. Sanofi respected the strict independence of JOGL, which administers its platform and the Co-Immune page in complete autonomy. Similarly, the Committee for Ethics, Science and Impact (CESI) was independent of Sanofi and decided alone on the strategic and scientific orientations of the program and the best projects to be rewarded. GF was paid by Just One Giant Lab to support the elaboration of the manuscript; provided consulting services to Vaccines Europe, a trade association based in Belgium and is a volunteer board member of the Coalition for Life-Course Immunisation, a UK-based charity ; no other relationships or activities that could appear to have influenced the submitted work.

URLs

Project name	URL
HERA: a mobile health platform to improve refugees' health	https://app.jogl.io/project/18
Qualitative analysis of Tweets on Vaccination	https://app.jogl.io/project/20
HEROIC Santé - Commit to get vaccinated and to promote vaccination	https://app.jogl.io/project/115
Project APRICOT	https://app.jogl.io/project/117
Vaccination Awareness Escape Game	https://app.jogl.io/project/22
Harmonize Vaccination	https://app.jogl.io/project/117
Pass it on: A game about vaccine hesitancy	https://app.jogl.io/project/70
Global Vaccination Risk Assessment	https://app.jogl.io/project/73
Immuno	https://app.jogl.io/project/9
Vaccine DataDump	https://app.jogl.io/project/26
Measuring vaccination hesitancy from social media	https://app.jogl.io/project/59
Mortality according to access to vaccines	https://app.jogl.io/project/60
The health system matrices	https://app.jogl.io/project/61
Meta immune - Data exploration of existing DB	https://app.jogl.io/project/63
Biloba (projet tiré de)	https://app.jogl.io/project/67
Wakuchin Senshi	https://app.jogl.io/project/68
Neutralizing information about vaccines	https://app.jogl.io/project/69
Go Viral !	https://app.jogl.io/project/71
Make Vaccines Affordable	https://app.jogl.io/project/72
Analyse de tweets liés à la vaccination	https://app.jogl.io/project/74
Detect vaccine administration in social media patient data	https://app.jogl.io/project/78
Detect vaccine hesitancy in social media patient data	https://app.jogl.io/project/79

References

1. Nosek BA, Alter G, Banks GC, et al. Promoting an open research culture. Science. 2015 June 26;3486242:1422–5. https://doi.org/10.1126/science.aab2374.

2. Burgelman J-C, Pascu C, Szkuta K, et al. Open Science, Open Data, and Open Scholarship: European Policies to Make Science Fit for the Twenty-First Century. Front Big Data. 2019 December

10;2:43. https://doi.org/10.3389/fdata.2019.00043.
3. Elliott KC, Resnik DB. Making Open Science Work for Science and Society. Environ Health Perspect. 2019 July;1277:075002. https://doi.org/10.1289/EHP4808.
4. Fraisl D, Campbell J, See L, et al. Mapping citizen science contributions to the UN sustainable development goals. Sustain Sci. 2020 July 2. https://doi.org/10.1007/s11625-020-00833-7.
5. Auffray C, Balling R, Blomberg N, et al. COVID-19 and beyond: a call for action and audacious solidarity to all the citizens and nations, it is humanity's fight. F1000Research. 2020 September 14;9:1130. https://doi.org/10.12688/f1000research.26098.1.
6. United Nations. Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. 2017 July 10.
7. World Health Organization. Global vaccine action plan 2011-2020. Geneva: World Health Organization; 2013. ISBN: 978-92-4-150498-0.
8. World Health Organization. Immunization coverage n.d. https://www.who.int/news-room/fact-sheets/detail/immunization-coverage (accessed October 8, 2020).
9. World Health Organization. Ten health issues WHO will tackle this year n.d. https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019 (accessed October 8, 2020).
10. World Health Organization. Immunization Agenda 2030: A global strategy to leave no one behind. 2020.
11. Chan MS, Jamieson KH, Albarracin D. Prospective associations of regional social media messages with attitudes and actual vaccination: A big data and survey study of the influenza vaccine in the United States. Vaccine. 2020 September 11;3840:6236–47. https://doi.org/10.1016/j.vaccine.2020.07.054.
12. Wouters OJ, Shadlen KC, Salcher-Konrad M, et al. Challenges in ensuring global access to COVID-19 vaccines: production, affordability, allocation, and deployment. Lancet Lond Engl. 2021 March 13;39710278:1023–34. PMID: 33587887. https://doi.org/10.1016/S0140-6736(21)00306-8.
13. World Health Organization. Vaccine Safety Net n.d. https://www.vaccinesafetynet.org/ (accessed October 8, 2020).
14. Boost Community | Accueil n.d. https://boostcommunity.org/ (accessed October 8, 2020).
15. Has Finland found an antivax antidote? - VaccinesToday n.d. https://www.vaccinestoday.eu/stories/has-finland-found-an-antivax-antidote/ (accessed October 9, 2020).
16. Vaccination Acceptance Research Network n.d. https://vaccineacceptance.org/ (accessed October 9, 2020).
17. World Health Organization. Voice, agency, empowerment - handbook on social participation for universal health coverage n.d. https://www.who.int/publications-detail-redirect/9789240027794 (accessed August 14, 2021).
18. Marston C, Renedo A, Miles S. Community participation is crucial in a pandemic. Lancet Lond Engl. 2020;39510238:1676–8. PMID: 32380042. https://doi.org/10.1016/S0140-6736(20)31054-0.
19. West J, Lakhani KR. Getting Clear About Communities in Open Innovation. Ind Innov. 2008 April;152:223–31. https://doi.org/10.1080/13662710802033734.
20. Liao CH. How to improve research quality? Examining the impacts of collaboration intensity and member diversity in collaboration networks. Scientometrics. 2011 March;863:747–61. https://doi.org/10.1007/s11192-010-0309-2.
21. Juan AA, Daradoumis T, Roca M, Grasman SE, Faulin J, editors. Collaborative and Distributed E-Research: Innovations in Technologies, Strategies and Applications. IGI Global; 2012. ISBN: 978-1-4666-0125-3 978-1-4666-0126-0.
22. Polk M. Transdisciplinary co-production: Designing and testing a transdisciplinary research framework for societal problem solving. Futures. 2015 January;65:110–22. https://doi.org/10.1016/j.futures.2014.11.001.
23. Leavy P. Essentials of transdisciplinary research: using problem-centered methodologies. Walnut

Creek, CA: Left Coast Press; 2011. ISBN: 978-1-59874-592-4 978-1-59874-593-1.
24. Stokols D. Toward a Science of Transdisciplinary Action Research. Am J Community Psychol. 2006 September;381–2:79–93. https://doi.org/10.1007/s10464-006-9060-5.
25. Nielsen MA. Reinventing Discovery: The New Era of Networked Science. Princeton, NJ, USA: Princeton University Press; 2011. ISBN: 978-1-4008-3945-2.
26. Franzoni C, Sauermann H. Crowd science: The organization of scientific research in open collaborative projects. Res Policy. 2014 February 1;431:1–20. https://doi.org/10.1016/j.respol.2013.07.005.
27. Vayena E, Brownsword R, Edwards SJ, et al. Research led by participants: a new social contract for a new kind of research. J Med Ethics. 2016 April;424:216–9. https://doi.org/10.1136/medethics-2015-102663.
28. Greshake Tzovaras B, Angrist M, Arvai K, et al. Open Humans: A platform for participant-centered research and personal data exploration. GigaScience. 2019 June 1;86:giz076. https://doi.org/10.1093/gigascience/giz076.
29. Lewis DM, Leibrand S, Street TJ, Phatak SS. Detecting Insulin Sensitivity Changes for Individuals with Type 1 Diabetes. Diabetes. 2018 May;67Supplement 1:79-LB. https://doi.org/10.2337/db18-79-LB.
30. Afuah A, Tucci CL. Crowdsourcing As a Solution to Distant Search. Acad Manage Rev. 2012 July;373:355–75. https://doi.org/10.5465/amr.2010.0146.
31. Sitruk Y, Kazakçi A. Crowd-based data-driven hypothesis generation from data and the organisation of participative scientific process. Des. 2018 Conf., Dubrovnik, Croatia: 2018 May. https://doi.org/10.21278/idc.2018.0510.
32. Anderson C. The End of Theory: The Data Deluge Makes the Scientific Method Obsolete. Wired. 2008 June 23. ISSN: 1059-1028
33. Bosman J, Bruno I, Chapman C, et al. The Scholarly Commons - principles and practices to guide research communication. Open Science Framework; 2017 September 15. https://doi.org/10.31219/osf.io/6c2xt.
34. Hecker S, Haklay M, Bowser A, Makuch Z, Vogel J, Bonn A, editors. Citzen Science – Innovation in Open Science, Society and Policy. UCL Press; 2018 October 15. ISBN: 978-1-78735-235-3 978-1-78735-234-6 978-1-78735-233-9 978-1-78735-236-0 978-1-78735-237-7 978-1-78735-238-4.
35. Katapally TR. The SMART Framework: Integration of Citizen Science, Community-Based Participatory Research, and Systems Science for Population Health Science in the Digital Age. JMIR MHealth UHealth. 2019 August 30;78:e14056. https://doi.org/10.2196/14056.
36. Rowbotham S, McKinnon M, Leach J, Lamberts R, Hawe P. Does citizen science have the capacity to transform population health science? Crit Public Health. 2019 January;291:118–28. https://doi.org/10.1080/09581596.2017.1395393.
37. Ramatowski JW, Lee CX, Mantzavino A, et al. Planning an innovation marathon at an infectious disease conference with results from the International Meeting on Emerging Diseases and Surveillance 2016 Hackathon. Int J Infect Dis. 2017 December;65:93–7. https://doi.org/10.1016/j.ijid.2017.09.025.
38. Angelidis P, Berman L, Casas-Perez M de la L, et al. The hackathon model to spur innovation around global mHealth. J Med Eng Technol. 2016 November 16;407–8:392–9. https://doi.org/10.1080/03091902.2016.1213903.
39. Kienzler H, Fontanesi C. Learning through inquiry: a Global Health Hackathon. Teach High Educ. 2017 February 17;222:129–42. https://doi.org/10.1080/13562517.2016.1221805.
40. D'Ignazio C, Klein LF. Data feminism. Cambridge, Massachusetts: The MIT Press; 2020.
41. Costanza-Chock S. Design justice: community-led practices to build the worlds we need. Cambridge, MA: The MIT Press; 2020. ISBN: 978-0-262-04345-8.
42. DePasse JW, Carroll R, Ippolito A, et al. Less noise, more hacking: how to deploy principles

from MIT's hacking medicine to accelerate health care. Int J Technol Assess Health Care. 2014 July;303:260–4. https://doi.org/10.1017/S0266462314000324.
43. Day K, Humphrey G, Cockcroft S. How do the design features of health hackathons contribute to participatory medicine? Australas J Inf Syst. 2017 March 8;21. https://doi.org/10.3127/ajis.v21i0.1383.
44. Pan SW, Stein G, Bayus B, et al. Systematic review of innovation design contests for health: spurring innovation and mass engagement. BMJ Innov. 2017 October;34:227–37. https://doi.org/10.1136/bmjinnov-2017-000203.
45. Benchoufi M, Fournier M, Magrez D, et al. Epidemium: A multidisciplinary community to tackle cancer using big and open data. J Clin Oncol. 2018 May 20;3615_suppl:e13604–e13604. https://doi.org/10.1200/JCO.2018.36.15_suppl.e13604.
46. Are Civic Hackathons Stupid? BloombergCom. 2013 July 5.
47. Tress B, Tres G, Fry G, Opdam P. From Landscape Research to Landscape Planning: Aspects of Integration, Education and Application. Springer Science & Business Media; 2005 October 25. ISBN: 978-1-4020-3978-2.
48. Argote L, Ingram P. Knowledge Transfer: A Basis for Competitive Advantage in Firms. Organ Behav Hum Decis Process. 2000 May;821:150–69. https://doi.org/10.1006/obhd.2000.2893.
49. Attwell K, Betsch C, Dubé E, et al. Increasing vaccine acceptance using evidence-based approaches and policies: Insights from research on behavioural and social determinants presented at the 7th Annual Vaccine Acceptance Meeting. Int J Infect Dis IJID Off Publ Int Soc Infect Dis. 2021 April;105:188–93. PMID: 33578012. https://doi.org/10.1016/j.ijid.2021.02.007.
50. Peach K, Berditchevskaia A, Bass T. The collective intelligence design plyabook. Nesta's Centre for Collective Intelligence Design. n.d.
51. Co-Immune: a case study on open innovation for vaccination hesitancy and access | Zenodo n.d. https://zenodo.org/record/4560273#.YVYlGZpBzb2 (accessed September 30, 2021).
52. Luo EM, Newman S, Amat M, et al. MIT COVID-19 Datathon: data without boundaries. BMJ Innov. 2020 August 31:bmjinnov-2020-000492. https://doi.org/10.1136/bmjinnov-2020-000492.
53. Kinder F, Harvey A. Covid-19: the medical students responding to the pandemic. BMJ. 2020 June 15:m2160. https://doi.org/10.1136/bmj.m2160.
54. Brereton B. EUvsVirus Hackathon project: A case study from a mentor's perspective. Irel J High Educ. 2020 June 30;122. ISSN: 2009-3160.
55. Kim JK, Kim HK, Oh HY, Ryu YU. A group recommendation system for online communities. Int J Inf Manag. 2010 June;303:212–9. https://doi.org/10.1016/j.ijinfomgt.2009.09.006.
56. Fagerholm F, Guinea AS, Münch J, Borenstein J. The role of mentoring and project characteristics for onboarding in open source software projects. Proc. 8th ACMIEEE Int. Symp. Empir. Softw. Eng. Meas. - ESEM 14, Torino, Italy: ACM Press; 2014, p. 1–10. ISBN: 978-1-4503-2774-9.
57. Schilling A, Laumer S, Weitzel T. Train and retain: the impact of mentoring on the retention of FLOSS developers. Proc. 50th Annu. Conf. Comput. People Res. - SIGMIS-CPR 12, Milwaukee, Wisconsin, USA: ACM Press; 2012, p. 79. ISBN: 978-1-4503-1110-6.
58. Bolar KP. Motives behind the use of social networking sites: an empirical study. IUP J Manag Res. 2009;81:75.
59. Ross-Hellauer T, Deppe A, Schmidt B. Survey on open peer review: Attitudes and experience amongst editors, authors and reviewers. PLOS ONE. 2017 December 13;1212:e0189311. https://doi.org/10.1371/journal.pone.0189311.
60. Van Noorden R. Online collaboration: Scientists and the social network. Nature. 2014 August;5127513:126–9. https://doi.org/10.1038/512126a.
61. Je-S Handbook n.d. https://je-s.rcuk.ac.uk/Handbook/Index.htm (accessed October 9, 2020).
62. Cohn JP. Citizen Science: Can Volunteers Do Real Research? BioScience. 2008 March 1;583:192–7. https://doi.org/10.1641/B580303.

63. Benkler Y, Nissenbaum H. Commons-based Peer Production and Virtue. J Polit Philos. 2006 December;144:394–419. https://doi.org/10.1111/j.1467-9760.2006.00235.x.

Supplementary information

Supplementary Method: comparing JOGL with other platforms

Selection of comparative platforms

In order to situate the action and suitability of JOGL as a host for Co-Immune, we selected popular social networks, science publishing and collaboration websites, and citizen science and project creation websites as elaborated on below.

Social networks: We selected platforms for which the primary focus is the connection of people and thoughts, without focus on projects or third person entities- they are dedicated to the self, and fulfil social needs, from chatting to self-promotion and networking [58]: LinkedIn, Instagram, Quora, Facebook, Twitter, Discord, Reddit and Mind.

*Science publishing and collaboration site*s: These platforms are not focused on the self, but instead on third person goals such as manuscript edition and curation, project creation or grant acquisition. We selected: Nature, Open Peer Review MNI, OSF collaboration, BioRxiv, pubpub, easychair, Je-s system, Research Gate, Academia, Mendeley and mySociety (RSB) [59–61].

Citizen science and project creation sites: These tools enable a commons based peer production, using open science, crowdsourced data collection, collaboration or challenge-based approaches: Kaggle, Hackaday, Experiment, Open Humans, Zooniverse, Instructables, Wikipedia, FlossManuals [62, 63].

Social network feature comparisons method

We evaluated the presence (1) or absence (0) of 42 features across these platforms that were manually selected for their relevance with the organisation of the Co-Immune programme. Features encompass communication, collaboration, and participant behavior. Platform clustering was performed using correlation distance and average linkage method. In order to gain insights on the proximity between platforms and take into account correlation between features, we performed a principal component analysis (PCA) and projected platform feature vectors on the top two eigenvectors (Fig S1). This allowed us to visualise the 3 types of platforms (colors). The top eigenvector, concentrating most of the variance across features, segregates social networks from scientific and project-based platforms. The second component in turn separates publication from peer-production platforms. This allows us to situate JOGL in a central position with respect to the first component (mixing science and social network), while clustering it with peer-production platforms.

Supplementary Table 1. Co-Immune partners

Supplementation Table 1. Co-Immune partners

Partners	Status	Activity
Sanofi	Private	Healthcare Industry
S3 Odéon	Non-profit	Communication And Event
Epitech	Private	Education
CorrelAid	Non-profit	Innovation And Technology
SUP biotech	Private	Education
Excelya	Private	Research
Wild Code School	Private	Education
Girls in Tech	Non-profit	Innovation And Technology
Kap Code	Private	Innovation And Technology
TUBA	Non-profit	Incubator
Data for good	Non-profit	Incubator
Maddy Keynote	Private	Communication And Event
Change Now	Private	Communication And Event

Supplementary Table 2. Project Assessment grid

Co-Immune | Project Assessment

Congratulations for being part of our reviewers! You are going to play a very important role in the future of projects that could help humanity solve one of its great challenges, better health for all. Thank you!

Co-Immune is an open and collaborative research and innovation program carried out by the NGO Just One Giant Lab, which aims to contribute to improving vaccination coverage in France and across the globe. (More on app.jogl.io/program/coimmune)

Scores you attribute will be used by the honorary and independent Committee for Ethics, Science and Impact (CESI) of the Co-Immune program to attribute prizes on the 18th of December in Paris during the Co-Immune ceremony. Register for the event here http://bit.ly/co-immune_ceremony !

More information on the evaluation framework and prizes here: http://bit.ly/assessment-framework

WHEN?
This form is to be completed by the 16th or the 17th of December.

WHY?
This form will allow you to evaluate the projects submitted to the Co-Immune program, The scores and comments given will be used to assess the approach, implementation, and impact of each project.

WHAT?
We kindly request you to provide independent, fair, unbiased and constructive feedback. No conflict of interest with the Co-Immune financing partner shall be accepted.

HOW?
Assessment is made anonymously. JOGL will not share your name or contact information to any participant.
The comments given here will be made public on the platform. However, the given scores will be hidden to the public. Your identity will remain anonymous unless you purposely waive your anonymity.

QUESTIONS ?
If you have any questions, please, feel free to contact JOGL at hello@jogl.io

READY? GO!
* Required

1. Email address *

2. Your first name and last name *
This information is only used by JOGL for admin purpose and will not be made public. This evaluation is anonymous.

3. Please provide information regarding your current or previous links of interest with Sanofi, the main financial partner of the Co-Immune program. *

Mark only one oval.

- I certify I have no link of interest with Sanofi
- I have links of interest with Sanofi. Therefore, I regrettably cannot take part in the project assessment

4. Link of the project page being reviewed *
You can find the list of links and names of projects to review here: http://bit.ly/active-projects-links

Project Approach

In this section, you will assess the approach of the project. Please rank from 1 to 5 each criteria below. You can provide additional comments in the appropriate field.

5. The clarity and relevance of the problem that the project is attempting to solve and alignment with the Co-Immune program's scope [Score] *
1. Unclear and/or irrelevant | 3. Clear but relevant points are missing | 5. Very clear and relevant

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

6. The clarity and relevance of the problem that the project is attempting to solve and it's alignment with the Co-Immune program's scope [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

7. Fit between the project's approach/methodology and the problem they have stated to resolve [Score] *

1. Inappropriate | 3. Appropriate | 5.Very appropriate

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

8. Fit between the project's approach/methodology and the problem they have stated to resolve [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

9. Introduction of ground-breaking objectives, novel concepts or approaches by the project [Score] *

1. Not innovative | 3. Innovative | 5. Disruptive

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

10. Introduction of ground-breaking objectives, novel concepts and approaches [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

Implementation

In this section, you will assess the implementation strategy of the project. Please rank from 1 to 5 each criteria below. You can provide additional comments in the appropriate field

11. The project's state of progress [Score] *

1. No results yet | 3. Some results but with a promising development plan | 5. Working proof of concept

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

15. The project's ability to actively engage and align itself with all the relevant groups and possible stakeholders [Score] *

1. Unaware | 3. Aware but unclear integration | 5. Actively engaged

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

16. Ability to actively engage and align itself with all the relevant groups and possible stakeholders [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

Impact

In this section, you will assess the impact of the project. Please rank from 1 to 5 each criteria below. You can provide additional comments in the appropriate field.

17. Clarity and relevance of the criteria used to measure impact [Score] *

1. Unclear and irrelevant | 3. Clear but not entirely appropriate | 5. Very clear and relevant

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

18. Clarity and relevance of the criteria used to measure impact [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

19. To what extent does the project takes into account its ecosystem (ecological, environmental, ethical and social considerations) [Score] *

1. Unaware | 3. Aware | 5. Very aware

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

20. To what extent does the project takes into account its ecosystem (ecological, environmental, ethical and social considerations) [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

21. The sustainability and scalability of the project in the long term [Score] *

1. No sustainability model and no scaling potential | 3. Sustainable and scalable but still unstructured plan | 5. Already applying a sustainable plan & good scalability

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

22. The sustainability and scalability of the project in the long term [Comment, optional]

Please, comment and explain the score you have given. You can also give constructive feedback to help the project improve on this criteria.

23. The project's dissemination strategy (quality of documentation for goals, results, methods and needs; open access model, outreach) [Score] *

1. Irreproducible and poorly documented 3. Good documentation but with few weaknesses 5. Easily reproducible & very well communicated

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

24. The projects dissemination strategy (quality of documentation for goals, results, methods and needs; open access model, outreach) [Comment, optional]

Additional comments and reviewer self-evaluation

You may provide below additional comments addressed to the team leaders of the project, and private comments to the JOGL team.

Please, also assess your expertise in the fields relevant to evaluate the project.

25. [To the team leaders] Other general constructive comments about the project *

26. [To JOGL] Private comment - anything you would like to inform the JOGL team of, privately.

27. What is your expertise that is relevant to evaluate this project? *

Please provide justification of your expertise if possible.

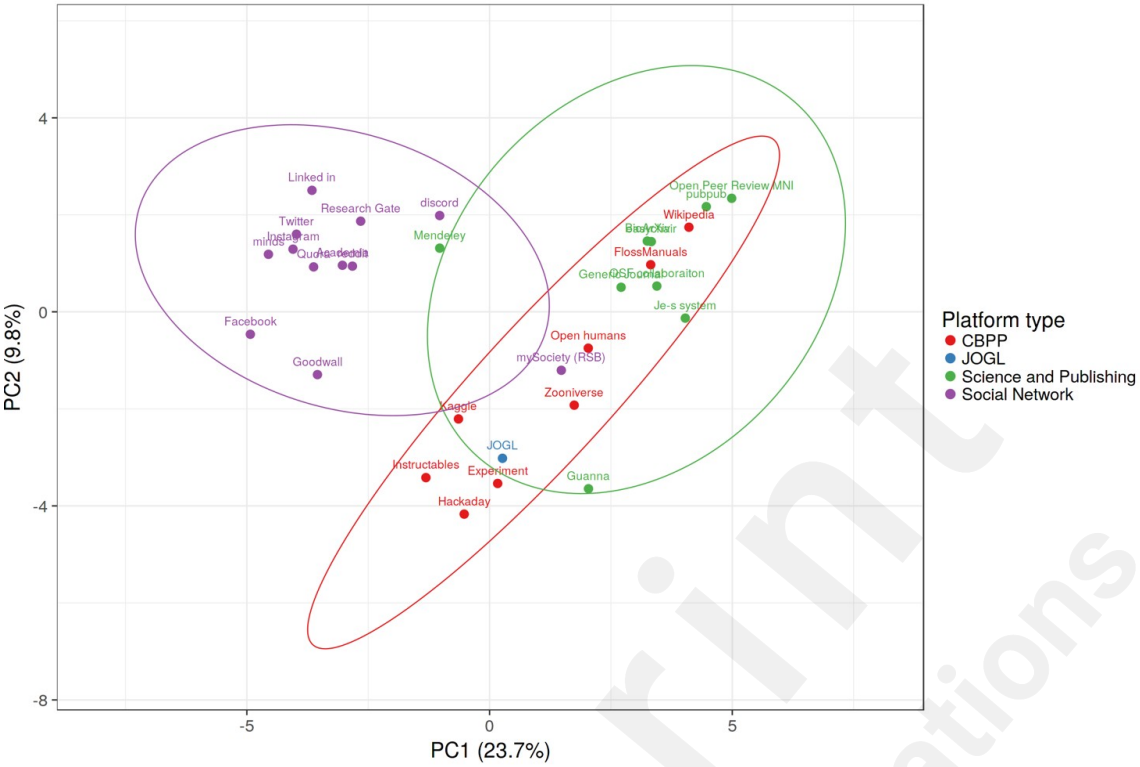
28. Would you like us to include you in our "Experts community" and provide similar reviews to projects when you have time in the future? *

Mark only one oval.

- Yes
- No
- Maybe

Thank you very much for your feedback!

Supplementary Figure 1. JOGLs position as a social network for Open Science



Supplementary Figure 1. JOGLs position as a social network for Open Science
Various online platforms represented in the first 2 components of a PCA based on their features from Figure 1. We use the pcaMethods R package with default parameters to calculate principal components. Catchment of groupings represent a 95% certainty interval of a platform landing within the platform type through feature space. N = 29 platforms, each with 42 true/false data points. CBPP- Citizen based peer production network.

Supplementary Files

Untitled.
URL: http://asset.jmir.pub/assets/4d0437c8c7745255ed7152141d0c1ddc.docx

Figures