

The Swedish mass experiments — a way of encouraging scientific citizenship?

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Abstract

Since 2009 Vetenskap & Allmänhet (Public & Science, VA) coordinates an annual mass experiment as part of *ForskarFredag* — the Swedish events on the European Researchers' Night. Through the experiments, thousands of Swedish students from preschool to upper secondary school have contributed to the development of scientific knowledge on, for example, the acoustic environment in classrooms, children's and adolescents' perception of hazardous environments and the development of autumn leaves in deciduous trees. The aim is to stimulate scientific literacy and an interest in science while generating scientific output. The essay discusses how the mass experiments can contribute to encouraging scientific citizenship.

Keywords

Citizen Science; Public Engagement with Science and Technology; Science Education

This paper provides an account of the annual Swedish mass experiment and relates this initiative to the phenomena of citizen science and scientific citizenship. The aim of the paper is to discuss and reflect on the mass experiment as a citizen science event and on its possible contribution to stimulating different aspects of scientific citizenship. For the purpose of the discussion, a short history of the volunteer contributor to science is given, after which the event is placed in the more general context of citizen science and different conceptualisations of scientific citizenship. *Citizen science*, as a concept, usually denotes practices of volunteers aiding scientists in the gathering and classification of data. *Scientific citizenship* on the other hand, is primarily associated with citizens engaging in discussion on the roles of science and research in society, or by influencing policy decisions through the creation of scientifically valid data on local environmental problems.

Volunteer contributors to science — a historical overview

Recently, scientists have turned to masses of online volunteers for help in analyses of very large sets of data. This is considered an important development for science. It offers an expansion of a workforce needed to work with large data sets and presents an attractive solution whenever observations or classifications cannot be automated using technologies. The attractiveness of the concept is increased by the fact that many scientific issues need to cover large areas for observations and classifications, preferably over longer time-spans [Field, Tyre and Possingham, 2005].

These initiatives have been coined *citizen science*, and the actors performing the tasks asked for by science, *citizen scientists* [Franzoni and Sauermann, 2014; Goodchild, 2007]. However, different forms of citizen science have different trajectories in terms of research, scientific output, hopes and expectations as well as funding structures.

The history of volunteer contributors to science includes the great impact of individuals, at a time when the professional scientist had not yet been invented. Darwin and Newton have, along with other great names, been assigned the epithet of citizen scientists [Silvertown, 2009]. Over the past centuries, often with the aid of new technologies, volunteers and amateurs took an active part in the production of knowledge and played a significant role in scientific work. This changed in the mid-20th century, as universities and governments gradually took financial stewardship of research and the sciences became increasingly professionalised [Star and Griesemer, 1989].

The methods of involving non-scientists in scientific work evolved into their current shape in the post-war period. In terms of scientific output, the traces can be followed back at least to the mid-1960s.

The history of the amateur or volunteer contributing to science is however also a history of the publicity granted to these amateur helpers; the low profile of present-day amateur contributors is quite at odds with the high visibility of the great names of historical amateurs like Darwin. Among today's professional scientists the inclusion of the volunteer contributor in scientific work is always accompanied by the fear of bad data [Snow et al., 2008; Riesch and Potter, 2014]. This means that the contribution of non-scientists to science probably is far greater than has been acknowledged by science [Cooper, Shirk and Zuckerberg, 2014].

Conceptualisations of scientific citizenship and their relation to citizen science

The two main conceptualisations of scientific citizenship currently circulating were both conceived of in the mid-1990s. The first refers to *a representative stakeholder of relevant interests in the intersection of science and society*. Particularly present are issues involving environmental problems and risks, with the common denominator that scientific knowledge is contested as a basis for policy decisions. Here scientific citizenship often takes the form of deliberative initiatives and is acted out in negotiations between stakeholders affected by scientific knowledge, informing policy decisions [Irwin, 1995; Irwin, 2001; Hagendijk and Irwin, 2006].

The second conceptualisation of scientific citizenship relates to initiatives that depart from local problems, often concerning health or environmental issues such as pollution or the draining of natural resources. A distinct feature of this second conceptualisation is that *scientific output is not aimed for*. Rather, the main objective is typically to create data in order to influence political decision-making or legal processes. Even though these initiatives mainly exist outside the institutions of science, they still rely on scientific standards — and in many cases scientific laboratories or instruments, for creating valid data. The funding is often structured through NGOs or crowdfunding campaigns, and more seldom through traditional scientific funding. The participating citizens take an active role in defining the problem at hand as well as in the collection and analysis of the data [Ottinger, 2010; Orta-Martínez and Finer, 2010; Macey et al., 2014; Haklay, 2013].

Citizen science most often pertains to *the volunteer contribution of non-scientists to scientific work* [Silvertown, 2009]. With regards to the degree of volunteer involvement in the scientific work, different levels have been described in the literature. Most often, amateurs and volunteers are invited and relied upon for the collection and classification of data. Typically, the citizens are deployed to solve problems that cannot be automated, for example recognizing patterns in large datasets and conducting extensive fieldwork outdoors [Sullivan et al., 2009]. Data quality is usually assured by carefully designed and standardised protocols for participation, making citizens on par with scientists in terms of conducting empirical work. This type of relation closely encompasses the role of students, scientists and teachers in the Swedish mass experiment, as discussed below.

The relationship between more common forms of citizen science and scientific citizenship is complex and has not yet been sufficiently explored in research. Participating in citizen science initiatives is sometimes understood as stimulating scientific citizenship, due to expectations that participation and inclusion will promote a more democratic science, as evident in many policy documents on the EU level [Holocher-Ertl and Kieslinger, 2013; see also Nascimento, Pereira and Ghezzi, 2014].

Citizen science as a method in the natural sciences has been scientifically evaluated mainly in terms of data quality, but occasionally also in terms of pedagogy and learning. And while the first conceptualisation of scientific citizenship has been extensively researched by social scientists as a field of inquiry, resulting in a large body of knowledge in the domains of public engagement/public understanding of science, a much needed question to explore is *if*, and if so *how*, participation in citizen science is related to forms of scientific citizenship, and how they can benefit from each other. The possible role of the Swedish mass experiments in this regard is tentatively discussed below.

The Swedish mass experiments

The European Researchers' Night (ERN) is a European Commission initiative that attracts over 1 million visitors every year. Every year since 2005, on the last Friday of September, hundreds of activities are organised all around Europe with an aim of showing the general public — and in particular children and adolescents — how exciting research is, and that researchers are ordinary people with extraordinary jobs. Offered activities include different forms of experiments, science shows, exhibitions, science cafés, workshops, and science slams. [Holocher-Ertl and Kieslinger, 2013]

Since 2006 Vetenskap & Allmänhet (Public & Science, VA) is the national coordinator for the Swedish activities during ERN, which are organised by universities and science centres all over Sweden. In Sweden the name of the event is *ForskarFredag* ("Researcher Friday").

As part of *ForskarFredag*, VA coordinates an annual mass experiment, in which schools are invited to participate in real research in collaboration with professional researchers. The first mass experiment explored the air quality in Scandinavian classrooms and was held in 2009, in partnership with the Danish Science Factory and the Norwegian Research Council [Randall, 2010]. Since then VA has coordinated a further six national mass experiments in Sweden, which have

engaged thousands of Swedish school pupils, covering a wide range of research topics. In this context it should be noted that mass experiments are also arranged in connection with the European Researchers' Night by the previously mentioned organisations in Denmark and Norway.

Through the mass experiment VA seeks to address four aims:

- To give students an opportunity to participate in real research, introducing them to the scientific method and the systematic work of researchers, stimulating an interest in research.
- To help researchers obtain large amounts of data while engaging in dialogue with the participating students and teachers.
- To provide teachers with material and methods based upon state-of-the-art research to integrate into the curriculum.
- To assist science event organisers in attracting media attention, reaching potential visitors and stimulating public understanding of science.

The mass experiments — from preparations to follow-up

VA's role as a coordinator begins with the selection of the researcher/s to cooperate with on the mass experiment. This is done after a submission process, where researchers at the universities and research institutes of Sweden are invited to submit proposals for the mass experiment. Many aspects are taken into account in the selection of the experiment, such as feasibility (with regards to data quality — whether it is possible for pupils of a wide age range to carry out the tasks assigned to them; and how interesting/enjoyable/educational it would be for them), ethics and integrity, and that the experiment ideally should address topics of relevance for the everyday lives of the students. An underlying main principle is that the experiment should involve the students as research assistants and not research subjects. Thus proposals involving for example the collection of blood samples from participating students are routinely turned down.

Topics covered in past mass experiments include for example the acoustic environment in classrooms [Persson Waye et al., 2015], storage of refrigerated foods [Marklinder and Eriksson, 2015], children's and adolescents' perception of hazardous environments [Wall, 2014] and the development of autumn leaves in deciduous trees. The mass experiment of 2015 is on the decomposition of organic material in soil and its relation to climate change, studied with a newly developed, standardised method built upon the burying and weighing of tea bags [Keuskamp et al., 2013].

After the selection follows a close collaboration between the researcher and VA in order to design and optimise the experiment so that it will yield high quality data for the researcher and at the same time provide an interesting and enjoyable experience for the participating students.

Tasks carried out by students are generally based around documenting their observations — for example describing and taking photographs of hazardous environments, weighing tea bags or measuring the temperature in soil or in

refrigerators — under the supervision of their teachers. The amount of supervision and practical assistance required largely depends on the age of the participating students, which, since the first mass experiment, has often had a range from five to eighteen years.

VA takes care of the recruitment of classes to the experiment, primarily through invitations via its network of member organisations and local Researchers' Night event organisers, and by direct invitations to teachers who have participated in previous mass experiments, but also through press releases and to a lesser extent advertisements.

In collaboration with the researcher, VA produces a detailed teacher's manual covering the research question at hand, theory, background, aim, practical execution and suggestions on how the experiment can be integrated into the curriculum. Throughout the experiment VA functions as a link between the researcher and the classes, while at the same time encouraging and facilitating direct communication between the two, in particular through the use of social media before and during the experiment.

Other roles for VA include securing funding for the experiment (an annual European Researchers' Night grant has funded all but two experiments, which were funded by The Swedish National Food Agency and The Swedish Research Council Formas, respectively); handling communications and media work (including national and regional press releases as well as targeted contact with selected journalists); producing and disseminating a popular science report on the results of the experiment in cooperation with the researchers involved; and evaluating the mass experiment by means of a teacher survey.

In general the mass experiments receive extensive media coverage in national as well as regional and local news media, and in a variety of communication channels (TV, radio, online and print media).

The results of the mass experiments are communicated to a wide range of audiences: to participating schools by means of the popular science report, to the public primarily through mass media coverage and social media, and to the scientific community through the researchers' channels (publications, conferences, etc.).

A word on data quality

A fundamental aspect of the mass experiments is the quality of the data generated in the experiments. To participate in and contribute to real research, it is necessary for the students to provide the researchers with high quality data. The Swedish mass experiment relies on detailed instructions, carefully developed by the researcher in close collaboration with communication experts at VA. The opportunity for classes to engage in direct dialogue with the researcher via social media further reduces the risk for misunderstandings, as questions and ambiguities can be straightened out without time delay. Throughout the experiment, engaged teachers play a crucial role in explaining and contextualising the experiment for the students in addition to functioning as supervisors during the data collection phase of the experiment. An encouraging indication of the quality of the data is that so far three of the mass experiments have been published in well-renowned peer

reviewed journals [Randall, 2010; Persson Waye et al., 2015; Marklinder and Eriksson, 2015].

The mass experiment as a way to stimulate scientific citizenship

As mentioned above, the Swedish mass experiment is an example of citizen science where non-scientists assist scientists by gathering data. However, it might be argued that the event could foster an active scientific citizenship as well, particularly the first conceptualisation of scientific citizenship, by stimulating discussions on the role of science in addressing important societal issues.

It could be suggested that participating in real research could contribute to the students' developing an understanding of their own ability to play a part in the creation of important knowledge. The experiments could also encourage long-term engagement among the participating students for the societal challenges addressed in the experiments (e.g. climate change, nutrition and environmental issues) by promoting a perception of the challenges as concrete and quantifiable phenomena, to which it is possible to contribute to a solution by exercising different forms of scientific citizenship. The teacher evaluations from the Swedish mass experiments paint a positive picture of the presumed added value of participating in real research. Students are reported to take a keen interest in the experiments and the most important incentive to take part in the event is reportedly that it is about contributing to real research.

With regards to stimulating both citizen science and scientific citizenship among participating students, it can be argued that the main added value of the mass experiment is that the students' contribution results in "real science". The mass experiment in this respect provides an added value to the scientific experiments and demonstrations regularly performed in school as part of the curriculum. While important in the formal educational setting, these educational demonstrations do not provide the students with the experience of truly contributing to the advancement of science.

As a next step of furthering student engagement, VA will endeavour to include the students' experience of taking part as helpers to science in wider discussions of the relation between science and society and the scientific process. Information on this process and the scientific impact of the students' contribution in the mass experiment (e.g. publications based on the collected data) will be made part of the researchers' feedback to students and teachers. To promote feedback in the opposite direction — from students to researchers — VA recently hosted an online chat between the researcher and the participating classes in last year's mass experiment. The purpose was to create dialogue around the results and to capture any ideas the students may have for related future enquiries. Through these types of feedback, the classifications and observations performed by students can be discussed in a wider context of their possible implications for contributing to solving pressing issues of environmental and societal concern. In practice this could be viewed as bringing conceptualisations of scientific citizenship closer to practices of citizen science in making them benefit from each other.

Emerging concepts such as *Responsible Research and Innovation* (RRI) and *integrated science* have identified involving stakeholders and the public early in research processes as an important success factor for the ability of research and innovation

to be successful in tackling major societal challenges. To enhance the RRI aspect of the mass experiments, the students could be invited to take an active part earlier in the research process than at the data collecting stage. This could be done for example by including the students in the formulation of the research question, perhaps asking them to identify a local environmental issue to be explored scientifically, or they could be invited to submit research questions from which a professional researcher would pick out the mass experiment of the year. It could be argued that such active involvement at a more upstream point in the research process could potentially further stimulate scientific citizenship among participating students and teachers.

Concluding remarks

The Swedish mass experiment is centred on students and teachers contributing to scientific work with scientific output as the ultimate goal. As part of the European Researchers' Night (ERN), the mass experiments contribute to the event's overall goals of bringing researchers closer to the public and to improve understanding of the impact of the work of researchers on daily life, and encouraging young people to pursue a scientific career. The mass experiments' method of bringing researchers and the public closer together differs from other ERN activities, such as science shows and demonstrations, in that the students actually perform hands-on research together with professional researchers. The educational setting of the mass experiments further enhance discussion on the work of researchers, as the teachers provide contextualisation of the students' contribution, placing it in a wider societal context.

However, whether the students' contribution to science, valued by scientists, truly installs any aspects of a wider engagement or understanding of science on the students' part, is a question yet to be explored in research. In other words, does taking part in this type of citizen science projects make for scientific citizenship in any form? Currently there are to our knowledge no studies on relationships of these kinds. Future research could for example focus on the nature of the discussions that arise in the classroom before, during and after participating in the mass experiment, and on how upstream contributions to science can be facilitated.

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