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Comment

**NANOTECHNOLOGIES AND EMERGING CULTURAL SPACES FOR THE PUBLIC COMMUNICATION OF SCIENCE AND TECHNOLOGIES**

# NanoŠmano Lab in Ljubljana: disruptive prototypes and experimental governance of nanotechnologies in the hackerspaces

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*ABSTRACT: New forms of co-working spaces and community labs, such as Hackerspaces and Fablabs, but also open science and citizen science initiatives, by involving new actors often described as makers, tinkerers, and hackers enable innovation and research outside the walls of academia and industry. These alternative and global innovation networks are test beds for studying new forms of public engagement and participation in emergent scientific fields, such as nanotechnology. The article shows how these grassroots and Do-It-Yourself (DIY) or Do-It-With-Others (DIWO) research subcultures connect politics with design, community building with prototype testing, and how they establish an experimental approach for policy deliberation. We will consider a case study of a temporary, ad hoc and mobile NanoŠmano Lab in Ljubljana, Slovenia, which specializes in nanoscale materials and designs, to demonstrate the potential of prototypes and collective tinkering to become models for public involvement in emergent science and technology fields. This Hackerspace model of governance offers an alternative to the usual route of disruptive innovation, which starts in the R&D laboratory where it waits to be scrutinized by some government or regulatory body and be utilized by a start-up or mega corporation, and only then be safely taken up by the public. Hackerspaces operate through "disruptive prototypes" that create decentralized and nonlinear value chains and interactions between research, design and policy. Adoption of technology goes hand in hand with collective tinkering, and deliberation and assessment are happening simultaneously while prototyping. In this sense, disruptive prototypes can be said to support experimental governance. This policy closely follows some recent calls for "greater reflexiveness in the R&D process" via anticipatory policy and real-time assessment approaches, rather than more common, timeworn precautionary principles.*[1,2]

## 1. Introduction

Various attempts to involve citizens in research and the early stages of science policy formation are meant to restore and support the public trust in both science and policy.[3,4] Instead of communicating and disseminating results about which scientists and policy makers eventually agree, these new models of engagement inspire the public to take an active part in the whole process of discussing, negotiating, and making decisions on funding, risk assessment, transfer of knowledge, safeguarding etc. of an emergent scientific field. While this engagement improves the democratic legitimacy of the decision-making, little is known about its impact on either the implementation of agreed policies or the commitment among stakeholders. The whole "participatory" turn in science policy[5,6] is still in a nascent stage, and the attempts to understand how it enables decision making and implementation open more questions than provide answers.[7,8,9]

We are starting to move away from the "diffusion model" of innovation and the "deficit model" of science communication to more holistic models of both adoption of emergent technologies and communication of science.[10,11] This radically transforms the idea of technocratic governance, embodied

 

in the famous 1933 Chicago World's Fair motto ("Science finds, genius invents, industry applies, man adapts"), and the subsequent biopolitical critiques of science and society interaction,[12] both of which identified science as an instrument of governance with a dangerous potential to control life itself. Since then, an alternative persuasive case has been made that knowledge and politics are more accurately perceived as more nonlinear, decentralized, and tentative phenomena and practices, open to negotiations between various actors and stakeholders (individuals, groups, institutions and publics). Consequently, there is a need to define science as an object rather than instrument of governance, similar to other human activities and practices that require balance and integration.[13,14] In this sense, the participatory models of public engagement and science policy are grounded in realizing the cultural, historical and social embeddedness of all sciences and knowledge (see the "civic epistemology" and the calls for "citizens with active role in the production and use of science" in Jasanoff[15]). Here, rather than diffusing innovation or disseminating results and policies, the goal of science communication is to democratize the whole process of their creation and open it to all stakeholders and actors.

## 2. Hackerspace governance

With the rise of hacking, making and other DIY activities, we are starting to witness an even stronger push in terms of participation and public involvement in science and policy. It is not solely due to the emerging citizen labs, maker fairs and hackerspaces involve various publics in the R&D processes of prototyping, appropriating, personalizing and innovating. What is more important is how, within the alternative R&D places, institutions and networks, science and technology become both an object and instrument of governance. Democratization of science is practiced rather than only communicated, and the right to understand and voice your opinion and concerns about science are levelled with the right to experiment, to test and gain a direct experience with scientific knowledge or technology and to influence further developments and adoption. In this new flat-world and flat-universe hackerspaces are amalgams of prototypes and communities: the processes of understanding and tinkering with various technologies go hand in hand with the processes of sharing knowledge and building a community and spaces around these technologies.[16]

These experimental and tentative collectives around tinkering with data, hardware tools, and various human and non-human actors (molecules, nanoparticles etc.) define policy as a conduct rather than policing. The goal is to experiment and understand the possibilities and limits and to search for models on how to share responsibility and integrate various legal, social, and even aesthetic aspects of emergent technologies, rather than only assess their social, natural and economic benefits risks and benefits. I will use an example of such a citizen run laboratory, NanoŠmano Lab, based in Lubijana (Slovenia), and a specific project (a DIY Gel electrophoresis chamber) to demonstrate how in the hackerspaces policy is defined as a design practice, rather than a communicative and discursive action. It will be shown that it worthwhile to think about the implications of this more experimental rather than deliberative approach to policy in science & technology.

## 3. NanoŠmano Lab in Ljubljana

The NanoŠmano Lab was initiated in 2010 by Stefan Doepner (from the F18 Institute), a sound artist with an interest in robotic arts, and the science educator Marc Dusseiller (Hackteria.org), in collaboration with Kapelica Gallery (Slovenia), which has specialized in art and science projects. The annual "public art-and-science lab for the nanoscale interface between life and the artificial" invites artists, hackers, scientists and the general public to come to their seriously participatory workshops. Everyone will directly experience nanotechnologies by developing DIY versions of the tools and protocols commonly used in the professional nanolabs.

NanoŠmano Lab refuses the stance of the usual art and nanotechnology framework of collaborations and residencies, and identifies rather with the Hackteria.org goal of developing a "Open Source Biological Art Project". It uses process-oriented and collaborative workshop, and defines its results as "wiki and witty", recipe style descriptions supporting an almost crafts approach to science. The conscious goal of this "nano-crafting" is not to impress or showcase the

nano-future, but to demystify nanotechnologies and invite lay people to repeat the experiments at home or other ad hoc laboratory venues.

The collective tinkering and experimentations typically start with an act of squatting in unexpected spaces: in 2012 a gallery, 2011 an abandoned bar and a community garden in 2012; with eyes peering out from the height of a 5 year-old, the kindergardenification of adults with careers and points of view makes a new time in which the collective manages to forget the normal taken for granted individual reality and define a new, liminal space of interactions and exchanges across disciplines, scales, and practices. After the creative shared appropriation of the strange space, the participants start to build low tech laboratory equipment they will need, such as for "DIY laser tweezer", an optical laser essential for any nano-intervention. These tools are then used for different kinds of art and science performances and integrated with previously developed projects, often involving microorganisms like tardigrades or daphnia.

The whole process is documented with technical, but also witty and poetic descriptions on the Hackteria wiki pages and sometimes even published in a type of "zine" or a booklet with illustrations ("NanoŠmano, NanoPunk, and the Hacking of Future", 2010). This booklet uses a fairytale illustrations, Taoist Lao Zui poem, parodic sketches and description of the DIY tools as a "protocol" on how to run such DIY nanolab. The nano-zines "NanoŠmano, NanoPunk, and the Hacking of Future" describes the prototypes, created in 2011, such as digital microscope NŠ DM 1.00 (for observing microorganisms to understand the nano-scale), then NanoŠmano Turnatble NŠ T 1.0 (enabling hearing nano-particles), and NanoŠmano Manipulator NŠ M 1.0, a tool for nano-art-fabrication, later developed into a printer for cell structures (Hacteria BioBot).

The workshops of the NanoŠmano Lab are simply places where nanotechnologies are demystified in order to allow interactions between various forms of knowledge and communities. The interdisciplinary cooperation and interactions between artists, designers, scientists and ad hoc visitors produce prototypes, which are used for experiments but also as material ways of deliberation upon the dangers as well as opportunities of nanotechnology. It is a site of translation between scientific knowledge and technological innovation produced in the official labs and the everyday interests, practices, and problems of the general public. These translations are happening through collective and global tinkering, building and testing of prototypes in inclusive local settings involving anyone with the stamina to tinker, learn, and share knowledge.

## 4. Disruptive prototypes: DIY Gel electrophoresis chamber

During the recent 2012 NanoŠmano lab one of the tools envisioned and hacked was the DIY electrophoresis chamber kit by Marc Duseiller, a co-founder of the lab and the Hackteria.org initiative on "open source biological arts, DIY Biology, and Generic Lab Equipment". The development process behind this DIY kit summarizes well and locates the complex interactions and negotiations between people, places and various actors in a broader class of similar hackerspace prototypes. A general explanation of the basic experimental policy based on DIY kits is offered.

The goal of every DIY kit is to use cheap, easily accessible materials to create something functional that may be easily reproduced, shared and further developed by the community. In the case of gel electrophoresis this meant to "build your own little device in an IKEA Tupperware" and cross the conventional barriers between home appliances (IKEA Tupperware), food available from the local store (Agar Agar, food colours, salt), pharmacy product (stainless steel syringe needles), etc. These appropriated tools connected to various aspects of our everyday life literally erased the exclusionary difference between a kitchen and a lab, between walking in a shopping mall and inventing tools. These open source lab hacks transform such walking into an exercise of imagination, and construction of lab equipment into almost a mission of appropriating various tools from consumer culture, all in order to serve the purpose of democratizing science.

Hacking lab, medical and kitchen equipment becomes a form of crafting, where we appropriate and use our common tools and everyday techniques embedded in our kitchens, malls etc. for supposedly complex science protocols. Hacking nanotechnology (nano-crafting and nano-tinkering) becomes a form of quilting, embroidering, and cooking rather than something programmatic — that someday will radically change our life, just like molecular gastronomy and its lab techniques improves our cooking etc. The ambitions of nano-crafting are almost opposite from what we usually read in the media, which present nanosciences as the next revolution, which will completely transform our everyday life and practices.

Here the everyday life is transforming the nanotechnological tools and practices. The common practices and tools reconfigure the emergent science and show how it is embedded and connected with some everyday events and phenomena, in order to democratize it further so it is understandable and hackable by anyone. Disruptive prototype in this sense reverses the value "network" of innovation and appropriation by returning it back to its origins and our common experience. In this sense it is almost like upcycling common everyday objects otherwise seen to be idle to become lab equipment.

The whole NanoŠmano Lab is such a disruptive prototype with a strange ability to connect and be promted by a full range of functions, practices, and people. In the documentation (Facebook photos) the various activities of experimenting, socializing, cooking, eating together and partying, discussing, working are happening simultaneously and influence each other. Also various stereo-typically stagnant materials now circulate freely and move around the space from the kitchen to the microscopes and performance stage, becoming food and objects of scientific and aesthetic interest, breaking all the laboratory rules. The uncanny connections are almost the goal, because rather than isolating and separating science form the everyday we need to understand their connections and develop these further. We are also gaining a personal experience on how it feels to be living, having fun and cooking around such nanotechnologies while tinkering and working on their prototypes. The 2012 NanoŠmano Lab even intentionally used an urban garden in the city centre of Ljubljana in order to imagine and test how it will feel to connect the future nanofarming practices with such alternative farming, and prepare for a potential DIY nanofarming future while imagining various strange scenarios of future nanofarming.

## 5. DIY Gel electrophoresis chamber as a policy prototype for emergent nanosciences

The DIY Gel electrophoresis kit was developed in Ljubljana (NanoŠmano Lab) and Zurich (Swiss Mechatronic Art Society) at several hackerspace workshops, then used and further improved in Zagreb during a festival and hacking workshop (I'MM Media lab Zagreb). I in the NanoŠmano Lab context it originally was part of the research into movements of small molecule and spherification, which relates to Marc Duseiller's specialization in microfluidics. In its next iterations in became a tool for food hacking experiments and even an artistic exploration of colorful gels. This close connection between prototype and community building and the unique dynamic between hacking and adoption are evident in early snaps of the kit shot October 8, 2012 (https://fbcdn-sphotos-c-a.akamaihd.net/hphotos-ak-ash3/576383_4818859036164_413355715_n.jpg). The original feedback from the science and hacker community in Ljubljana and Zurich assessed its technical merits, outlining the various ways in which electric fields created in the box manipulate biomolecules (DNA fragments, colloidal rods, micelles). We quickly see how these discursive interpretations and questions evolve and change: the simple IKEA Tupperware as a typical consumer product is slowly transformed from a tool for citizen science projects into a tool for design, art, education etc.

While typical gel electrophoresis boxes are used for separation of various DNA molecules (for example DNA from RNA etc.), here it becomes a tool for playing with food colouring. The original scientific function of separating the basic colours in the food coloured samples to show the processes of electrophoresis eventually fails. The tool then acquires completely new, more artistic and even comical functions. It represents a type of community driven innovation where the goals and functions of any tool are not given in advance, but discussed and tested only after a prototype is built and after various groups interact with it during the workshops. Like with any other open source hardware and software prototype, various interpretations, uses and further developments are always encouraged.

DIY Gel electrophoresis chamber is a simple policy prototype for public participation in emergent nanosciences (and biotechnologies), enabling anyone to build a tool through which they can experience one of the basic lab techniques of separating molecules of various sizes: they may also rethink the use of such tool for possible design or art projects or any other uses. The ad hoc and mobile nature of the tool, constantly shifting and transforming in the workshops and hackerspaces (NanoŠmano Lab 2012, Swiss Mechatronic Art Society, I'MM Media lab in Zagreb), allows people from diverse cultures and disciplines to meet and interact. Even the simple act of posting the picture of the first version of the tool on Facebook triggered such interactions. The first question was from a graduate student in Indonesia (UGM university) who cooperates with Marc Duseiller on science workshops for schoolchildren. It was almost an instant request to explain the function of this kit and how it can help children learn something new about science. Another fellow hacker from the Swiss Mechatronic Art Society sent a warning

pointing to cheaper and simpler techniques of building such tools, and a Slovenian artist sent an explanatory account of electrophoresis. There is even a parodic response (from the author of this article) claiming this form of electrophoresis actually supports modernist aesthetic, and that the food color cubes are some tribute to abstract art and Malevich accusing Marc Duseiller of becoming a bioartist and betraying the DIYbio science.

The disruptive prototypes have simply a magical and anarchistic capacity to accommodate various uses, dreams, goals and needs and to connect people, contexts and various materials. Tinkering with and around DIY tools thus enables people with idiosyncratic agenda to express their opinion, send feedback and think of a rage of potential uses of the tool for their own practices, and at the same time be exposed to and grasping the emergent science and technology issues. I have looked closely at contemporary 21st century life where the adoption of the new technology or tool is happening while collectively tinkering and prototyping in the workshops and deliberating online on its uses and assessing its impacts. Disruptive prototypes, such as this DIY electrophoresis box, become means and media of experimental governance based on unique interaction between science and community *and* connecting research, design, and policy by democratizing them.

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