Citizen Science and Open Design: Workshop Findings

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Introduction

An inherent link exists between making things and designing things, often relying on skills, knowledge, and tools, and working together to achieve outcomes. Conventional design and manufacture to date has been a closed system requiring professional skills. Traditional manufacture has required a significant initial financial investment for "tooling" to produce large volumes of product (i.e., for "mass production"). In contrast, Digital Manufacture (DM) or Rapid Manufacture (RM) is "the ability to manufacture parts of virtually any complexity [and] geometry entirely without the need for tooling." The latter offers lower financial entry-points and the ability to create bespoke products.[1] The following article weaves Open design, Digital Manufacture and Citizen Science together presenting findings from territory exploring workshops with lay users signposting opportunities and perceived detrimental factors.

Conceptual Territory

Digital Fabrication (DF) is democratising manufacturing by making product creation more accessible to laypeople. DF also is enabling design practitioners to respond to bespoke user requirements in low volumes. This evolution of manufacturing produces opportunities for low-finance ventures, low quantity batches and bespoke products to be realized. Open design (OD) is "a movement of open fabrication that is democratizing manufacture to the user, enabling them to create personal products in the future."[2] Igoe and Mota have argued that although "no one expects digital fabrication to replace conventional manufacture soon," DF contains the potential to shift who and what can fabricate products.[3] DF is becoming more common because more accessible computer-aided design (CAD) software packages and scanning inputs exist.

Open design not only provides access to design information and tools, but also creates a system that controls inputs to optimize outputs, with DF or RM processes achieving efficient results. Vanderbeek Says, "[d]esign has not only become user-centred; the user has become the designer"; in addition, constraining elements

1 Richard Hague, "Unlocking the Design Potential of Rapid Manufacturing," in *Rapid Manufacturing: An Industrial Revolution for the Digital Age,* ed. N. Hopkinson, Richard Hague, and P. M. Dickens (Chichester, UK: John Wiley, 2006), 5–18.

2 Evan Malone and Hod Lipson, "Fab@home: The Personal Desktop Fabricator Kit," *Rapid Prototyping Journal* 13, no. 4 (2007): 245-55.

3 Tom Igoe and Catarina Mota, "A Strategists Guide to Digital Fabrication," *Strategy + Business* 4 (2011).

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of the design process could eliminate pitfalls or complications of technologies.[4] An open design system also empowers amateurs to create their own solutions, unhindered by professional structures.[5] The accessibility of fabrication tools and design information could enable the public to make digital devices with limited technical skills. "Digital fabrication is enabling users to create their own products and solutions," requiring the restriction of either design or process knowledge to avoid negative results.[6] An example of open design is Open Structures, a platform that enables users to design parts within a modular grid.[7] The grid helps users create modular parts, components, or assemblies to be shared or edited online. These platforms indicate opportunities in product creation by downloading either files or lists of purchasable materials.

Citizen science (CS) is one of the names given to "the participation of non-scientists in the data collection for scientific investigation."[8] Other names include crowd science, civic science, and networked science. Citizen science "provides an indispensable means of combining environmental research with environmental education and wildlife recording."[9] Smart phones and their proliferation have opened up opportunities for data gathering in various locations, a tool Citizen science already uses. The advent of open platforms to create smartphone applications using built-in sensors and GPS locators has aided the uptake of citizen science, with "50% of the British public now owning [smartphones]."[10] In one example of a citizen science project, children living in rural Washington used their "bus journey to school to catalogue deer, elk, and domestic livestock sightings."[11] Citizens have proven willing to participate, support, and actively investigate nature; 600,000 participants joined in the "Big Garden Bird Watch" in 2011, initiated by the Royal Society for the Protection of Birds.[12]

A Defra white paper titled "The Natural Choice: Securing the Value of Nature" highlighted that "government and society need to account for the value of nature, particularly the services and resources it provides."[13] The paper emphasizes the importance of effective partnerships and of forming communities to manage environments. The scientific community, meanwhile, has been reticent in accepting citizen science as productive, noting its lack of rigorous audit "to authenticate its validity."[14] Citizen science practices could embrace Ready-to-assemble kits as a gateway to users creating data gathering equipment for scientific purposes.

Ready-to-assemble kits are not a new phenomenon; they previously have been used by children's toy manufacturers Meccano and Airfix, and the flat pack furniture company Ikea also foresaw the economic advantage of producing kits. Open Hardware adopts a similar approach to Ikea's component furniture but makes the 'parts' accessible via the Internet. People with knowledge, located across the globe, can create products using digital

4 Sanne van der Beek, "From Representation to Rhizome: Open Design from a Relational Perspective," *The Design Journal* 15, no. 4 (2012): 423-41.

5 Bas van Abel, *Open Design Now: Why Design Cannot Remain Exclusive* (Amsterdam: Bis, 2011), 20.

6 Jamais Cascio and Alex Soojung-Kim Pang, "Manufacturing: Do it yourself? Ten Year Review," Institute for the Future (Fall 2007): 1-8.

7 Thomas Lommee, "Open Structures Exploring the Possibility of a Modular Construction Model," at www.openstructures.net/ (accessed December 12, 2012).

8 Tracy Lee, Michael S. Quinn, and Danah Duke, "Citizen Science, Highways and Wildlife: Using a Web-based GIS to Engage Citizens in Collecting Wildlife Information," *Ecology and Society* 11, no. 1 (2006):11.

9 H. E. Roy, M.J.O. Popcock, C. D. Preston, D. B. Roy, and J. Savage, *Understanding Citizen Science and Environmental Monitoring* (London: Centre for Ecology & Hydrology, Natural Environment Research Council, 2012), 11-18.

10 H. E. Roy, M.J.O. Popcock, C. D. Preston, D. B. Roy & J. Savage, *Understanding Citizen Science and Environmental Monitoring* (London: Centre for Ecology & Hydrology, Natural Environment Research Council, 2012), 18.

11 Aaron W. E. Galloway, Robert J. Hickey, and Gary M. Koehler, "A Survey of Ungulates by Students along Rural School Bus Routes," *Society and Natural Resources* 24, no. 2 (2011): 201-04.

12 HM Government, *The Natural Choice, What the Environmental White Paper Means for You* (London: Defra, 2012), 54.

13 HM Government, *"The Natural Choice: Securing the Value of Nature,"* vol. 8082 (Stationery Office, 2011), 3.

14 David G. Delaney, Corinne D. Sperling, Christiaan S. Adams, and Brian Leung, "Marine Invasive Species: Validation of Citizen Science and Implications for National Monitoring Networks," *Biological Invasions* 10, no. 1 (2008): 117-28.

kits. Electronics kits, so-called "little bits, a library of electronic modules that snap together," are already widening the accessibility of electronics.[15] The kit modules can be connected together, taking on the functionality governed by the user. Open design and digital fabrication can build on mass-produced components and kits to make niche or bespoke products.

An example kit requiring technical competence is the "The Air Quality Egg," a "community-led air quality sensing network giv[ing] people a way to participate in the conversation about air quality."[16] The digitally fabricated project is based on open source concepts, enabling the public to monitor for nitrogen dioxide and carbon monoxide, two common air pollution elements. Designers of the Air Quality Egg are aware that it cannot compete with more expensive monitoring equipment, but they are trying to create a network of sensors with a large range of readings. The Air Quality Egg is a good example of an open product, aimed at a technical user.

The territory of open design, citizen science, and digital manufacture presents new opportunities for the public or laypersons to create personal sensing or environmental monitoring equipment. These activities rely on access to parts and the knowledge to implement them. Previous examples have highlighted the creation of products by lead users for personal or immediate community use. Although some have argued that "technology and the capabilities to create products will become more accessible," they also recognize that "people will still need advice on their applications, distilling user insights into possible concepts."[17] With such support being made available, we can imagine that laypersons could create devices to address personal or community needs, if the processes exist. Design knowledge could be packaged within parametric constraints, ensuring producible outputs. With this possibility in mind, we executed a series of workshops exploring the effects, opportunities, and negative factors that users might encounter if they fabricate monitoring equipment.

Individual Novices with Ideas: Workshop 1

The first workshops investigated individual requirements for designing of monitoring devices. These drop-in workshops of five minute durations were created and tested at different venues, including Future Everything, and Digital Shoreditch 2012. These conference events attract people from creative backgrounds both experts and accompanying laypeople. A "design probe" helped participants engage and contribute within a structured setting. A probe is a design tool that "help[s] users openly interpret and build on a concept within an area of interest."[18] Probes are "valuable in inspiring design ideas for technologies that could enrich people's lives in new and pleasurable ways," presenting insights for technological applications.[19] The workshops tried to "humanize

15 LittleBits, "An Open Source Library of Electronic Modules that Snap Together with Magnets for Prototyping, Learning and Fun", http://shop.littlebits.com/products (accessed March, 13, 2013).

16 Edward Borden, "Air Quality Egg, Giving People Access to Participate in the Discussion Concerning Air Quality", http://airqualityegg.com/ (accessed March 11, 2013).

17 Dan Tynan, "The Next 25 Years," *PC World* episode 26, 3, 03 (2008): 109-12.

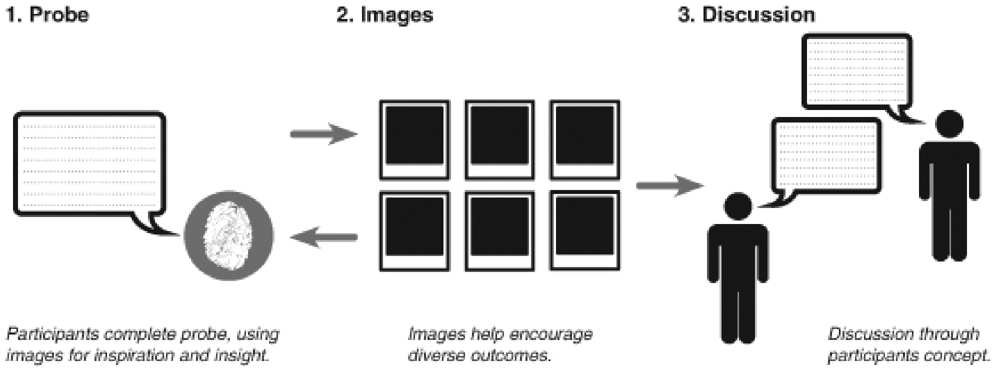


Figure 1
Process of Workshop.

18 Gerry Gaffney, "What is a Cultural Probe?" www.infodesign.com.au (accessed March 26, 2012).

19 William Gaver, Andy Boucher, Sarah Pennington, and Brendan Walker, "Cultural Probes and the Value of Uncertainty," *Interactions* 11, no. 5 (2004): 53-6.

20 Susan W. Hardwick, "Humanising the Technology Landscape through a Collaborative Pedagogy," *Journal of Geography in Higher Education* 24, no. 1 (2000): 123-9.

21 William Gaver, Andy Boucher, Sarah Pennington, and Brendan Walker, "Cultural Probes and the Value of Uncertainty," *Interactions* 11, no. 5 (2004): 53-6.

22 Groundspeack, "Geocaching, the Official Global GPS Cache Hunt Site", www.geocaching.com/ (accessed January 27, 2013).

23 H. E. Roy, M.J.O. Popcock, C. D. Preston, D. B. Roy, & J. Savage, *Understanding Citizen Science and Environmental Monitoring* (London: Centre for Ecology & Hydrology, Natural Environment Research Council, 2012), 10.

24 Robert Phillips, Sharon Baurley, and Sarah Silve, "The Practical Maker: Investigating the Definitions and Requirements of and Exploring the Motivations Behind Bespoke Making" (Crafting the Future, 10th European Design Conference, University of Gothenburg, 2013), 8.

the technology" for easy engagement.[20] The probe gave participants a framework within which to select a human sense, as a technological analogy, and to design a personal scenario responding to the following questions:

1. What information would this super-sense gather for you?
2. What information would this sensing ability help you gather from your outdoor environment?
3. What could the sensor say/communicate to you?
4. What would your sensor say to other people via the Internet?
5. Who else would be interested in what your sensor is saying?

We undertook the workshop recognizing that the designing of "open tasks [can] ensure that the results will be surprising."[21] To inspire participants, a display of hobbies (see Figure 3) and daily situations was presented. The images ranged from common outdoor hobbies (e.g., fishing and climbing) to the less familiar, "geocaching"—a free, real-world, outdoor treasure hunt in which players locate hidden containers, called geocaches, using a smartphone or GPS and sharing their experiences online.[22] The hobby images pointed toward "outdoor pursuits" because citizen science usually conducts "environmental monitoring" in outdoor locations.[23] Using hobbies in our workshops had two functions:

1. Opening participants' thinking outside their immediate working lives or the event's context.
2. Enabling participants to create devices that gather data for third parties while pursuing leisure activities.

Discussions were held while the participants worked because previous research had shown that participants would have a hard time "think[ing] outside of their daily activities."[24] The intention was to remove the barriers of competency of constructing monitoring technologies and to investigate people's motivations, reviewing the processes for sharing gathered data.

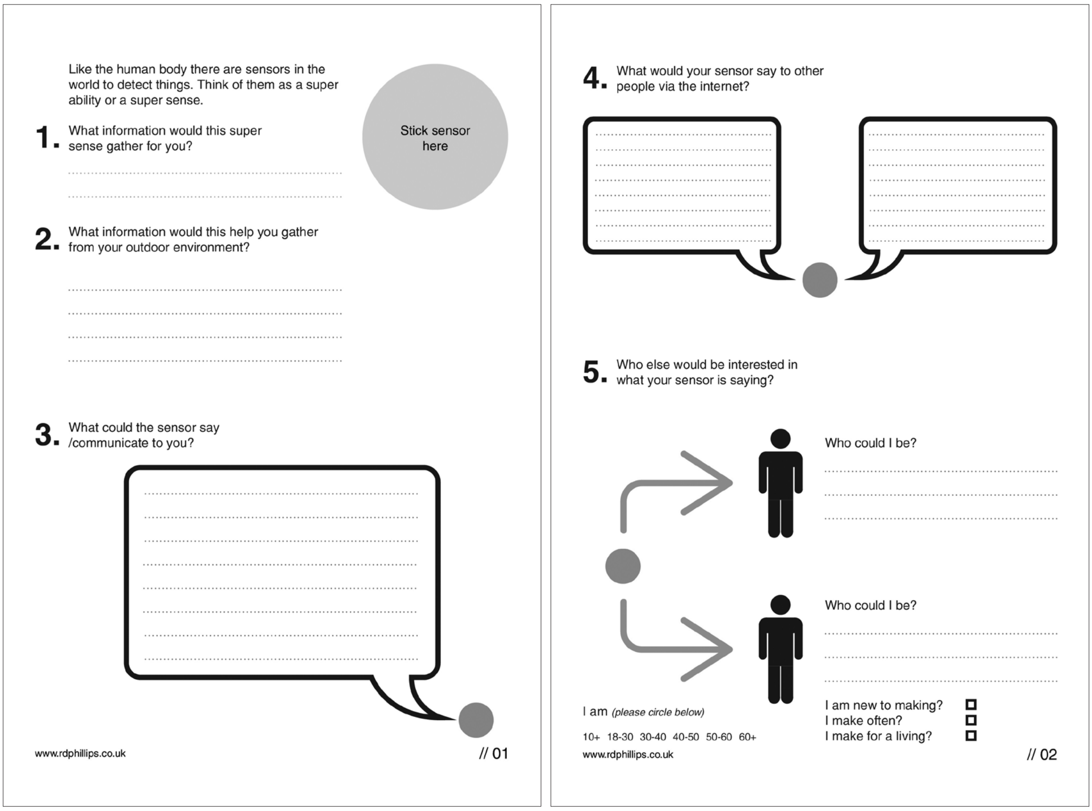


Figure 2 and Figure 3
Design Probe (Workshop 1).

Results from the 'novice workshops' formed insights that we later discuss, but on the whole, participants created inwardly looking and self-beneficial solutions. The insights garnered from the workshop contributed to methodological findings recognizing that participants need a structure within which to design when thinking about the wider implications of their work or fabrications. "Giving a creative practitioner a structure or restrictions channels the process, [which] leads to great innovation"; the results of the workshop emphasized that providing accessible tools in isolation from a technically capable "community" is not enough.[25]

Community of Amateurs with Common Goals: Workshop 2

Whereas the first workshops investigated individual requirements, they made clear that participants need a structure, context, and scenario to develop concepts, regardless of technological knowledge. This finding raised wider questions, including questions of whether communities (rather than individuals) would respond differently to creating sensing equipment and whether they might address global requirements. Various communities that already rely on "environmental knowledge" for their activities were considered. For the next workshop, we selected beekeepers because of their seasonal requirements, reliance on environmental knowledge, and benefit from shared community information.

25 Neil Maiden, Suzanne Robertson, and Alexis Gizikis, "Provoking Creativity: Imagine What Your Requirements Could Be Like," *Software, IEEE* 21 (2004): 68-75.

Figure 4
Wall of inspiration (Workshop 1).

Beekeeping has become more complicated in recent years because of viruses, the varroa mite, and, in particular, "colony collapse disorder" (CCD), which is alleged to be causing "the vanishing of the bees."[26] Commercial beekeepers have reported hive losses of up to 90% since 2006 as a result of CCD.[27] Because of their vital pollinating activities, bees are one of the most ecologically useful and important insects.[28] Bees can visit 1,500 flowers and fly up to 500 miles in their life time. This tremendous amount of work equates to a large percentage of the pollination necessary for our food chain: According to 'The Vanishing of the Bees' "without bees McDonald's would only have the buns to sell."[29] The issues facing bees and beekeepers present different challenges, engaging wider communities, and more parties are interested in the harvested data. The hobby aspect of beekeeping builds on the first workshop, in that the participants were amateurs. The beekeepers agreed to participate by self-selection through on-line recruitment. The workshop used posters to aid participants' inputs, posing the following questions:

1. What would you like the hive to say to you?
2. What would you like to say to the bee hive?
3. What would you specifically like the interior of the bee hive to say?

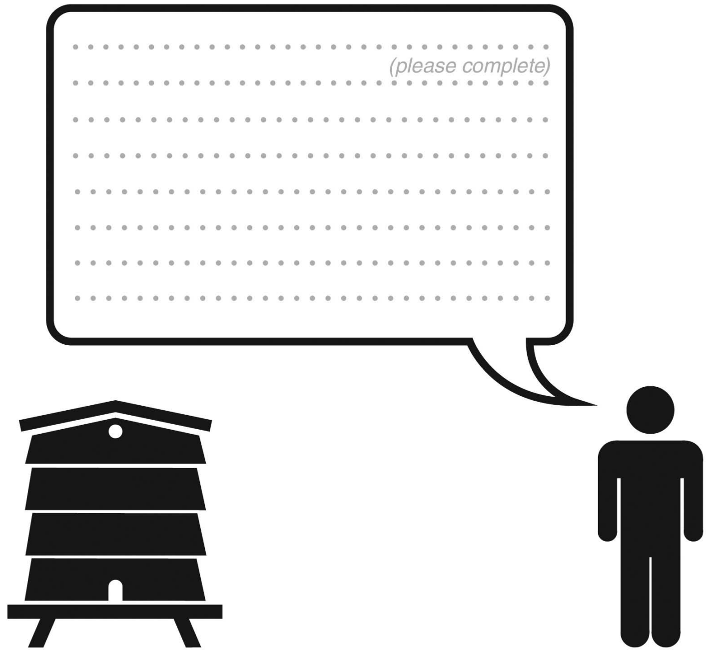
26 George Langworthy (Producer/Director) and Maryam Henein (Director), *The Vanishing of the Bees,* DVD (USA: Hive Mentality Films, 2009).

27 Alison Benjamin and Brian McCallum, *A World Without Bees,* (London: Guardian Books, 2009), 10.

28 David Cramp, *The Complete Step-by-step Book of Beekeeping,* (Leicestershire: Lorenz Books, 2011), 10.

29 Langworthy and Henein, *The Vanishing of the Bees.*

Figure 5
Excerpt from poster (Workshop 2).



4. What information from the areas surrounding the bee hive would you like to know?
5. What would you like the hive not to say publicly?

The beekeepers were interested in individual and community data harvested from digital devices. The posters separated the workshop into digestible sections, for easier engagement by technological laypersons. The workshop guided participants from thinking about their own bee hive to considering a community of bee hives, and the effect that large data sets could have as a collective. Participants were interested in neighboring hives' activity information, which could not be verbally communicated by their peers.

Fears and Responses in Light of the Workshops' Insights

The insights have been categorized into the following topics: regulation and traceability, data use, motivations and reciprocity, perceived value, and trust—as these are seen by authors as stumbling blocks to the citizen science/open design partnership. The insights are trying to signpost; foreseen positive and negative effects, design opportunities, and negative factors influencing the open design and citizen science partnership. The common themes are supported both by extant literature and by contemporary projects (excluding intellectual property discussions) to contextualise possible scenarios.

Figure 6
Workshop in progress (Workshop 2).

Regulation and Traceability

Workshop insights. Participants discussed manufacturing standards for product safety and quality control in artifacts they already use. Workshop participants did not consider the quality control parameters of their creations because they did not consider the possibility that other parties would value their concepts.

Wider insights. According to the British Standards Institute (BSI), "[a] standard is an agreed way of doing something. It could be about making a product, managing a process, delivering a service, or supplying materials; standards can cover a huge range of activities undertaken by organizations and used by their customers."[30] The BSI produces standards ensuring that products meet contextual parameters. These standards are compiled by manufacturers, industry experts, and independent groups to protect users and ensure safety and production processes are consistent. The Air Quality Egg did not include calibration and standardization because of the expense; alternatively, the project is "interested in the critical mass of large trend data."[31] Creation of standards for open design and citizen science needs both to inform how users make objects and to establish protocols ensuring rigor in collated data. The benefits of standards is that they "ensure that products and services are safe, reliable, and of good quality. For business, they are strategic tools reduc[ing] costs by minimizing waste and errors, and increasing productivity."[32] Could standards inform digitally created components, resulting in user generated product analysis based on a particular platform or tool?

30 British Standards Institute, "What Is a Standard?" www.bsigroup.co.uk/en-GB/standards/Information-about-standards/what-is-a-standard/ (accessed March 13, 2013).

31 Edward Borden, "Air Quality Egg, Giving People Access to Participate in the Discussion Concerning Air Quality," http://airqualityegg.com/ (accessed March 11, 2013).

32 ISO Standards, "What Is a Standard" www.iso.org/iso/home/standards.htm (accessed March 13, 2013).

Traceability and quality control have traditionally been signified in a maker's mark. For example, hallmarks on silver products inform readers of the "material quality, location of manufacture, monarch, year of fabrication and the silversmith."[33] This procedure provides an accurate provenance for a product. Could technical administration information be imprinted into a product via digital fabrication processes, providing material specification for recyclability or replacement? Could kit-based products tell the assembler when they are "correctly assembled," thus catering to someone with limited technical knowledge?

When should a project be open, and when should it be regulated?
During Workshop 1, one participant created theoretical sensors to value objects based on information from touch. The participant would use the sensors estimated value information to subsequently steal high-value, portable items. Although novel, in discussion the participant expressed fear of the possibility that the device might be used against him as a professional shopkeeper. The concern raises the question of what elements of a project should be open.

Most participants considered the positive effects of "open sensing," but should design also guard against negative uses? Who is eligible to make this decision? In the early days of 3D printing, gangs used the technology to create ATM scanners and with the devices accrued US$4 million in a matter of days.[34] The ATM scanner is a simple piece of equipment that fits around a cashpoint's card entry slot; it is camouflaged but gathers financial data with every interaction.[35] Although we should not fear advances in technology, when should we consider issues of misuse?

For example, Defence Distributed is developing "fully printable firearms," trying to publish design files to create working components firearms.[36] The Texas-based project wants to "change the way that we think about gun control, testing the policy on how governments would behave if every citizen has near access to a firearm through the internet."[37] The design information consists of digital files—specifically, "stereo-lithography tessellation language files" (STLs), which are 3D printable files that can be edited with a high level of CAD skill.[38] The possibility that people might download firearms has caught American federal gun laws off-guard, as a "monolithic legal scheme erected with the belief that guns and gun components originate in industrial facilities."[39] At the time of this writing, manufacturing a firearm for private use is not illegal under U.S. law, although selling or passing ownership of that constructed firearm is.[40]

33 British Hallmarks, "Online Encyclopaedia of Silver Marks, Hallmarks & Maker's Marks," www.925-1000.com/british_marks.html (accessed March 13, 2013).

34 Brian Krebs, "Gangs Using 3d Printers for ATM Skimmers," www.krebsonsecurity.com (accessed June 12, 2011).

35 The Federal Bureau of Investigation, "Taking a Trip to The ATM? Beware of Skimmers," www.fbi.gov/news/stories/2011/july/atm_071411 (accessed December 10, 2012).

36 Defence Distributed, "The Home of The Wiki Weapon Project," http://defensedistributed.com/ (accessed May 18, 2013).

37 Defence Distributed (accessed May 18, 2013).

38 Tom Beard, "Machining From STL Files," *Modern Machine Shop* 69 (1997): 90.

39 Peter Jensen-Haxel, "3D Printers, Obsolete Firearm Supply Controls, and the Right to Build Self-Defense Weapons Under Heller," *Golden Gate UL Rev* 42 (2011): 447.

40 Bureau of Alcohol, Tobacco, Firearms and Explosives, "Frequently Asked Questions," www.atf.gov/firearms/faq/atf-f-4473.html (accessed May7, 2013).

Data Use

Workshop insights. Participants in both workshops considered the data they were generating; they addressed the immediate interrogation of environments that do not have an existing body of data for positive or negative use. Beekeepers aired concerns about producing accessible profiles of bee husbandry that might be used to publicly discredit them. They were concerned about their reputation and community respect, if individual beehive data was publically published.

One concept from Workshop 1 was the ability to see the provenance of foods, not by its packaging, but by its taste or touch—a potential upside of having a consumer-driven return to local produce. In discussions the participant did not want to know every detail of consumed food; what if they ingested something and then discovered disturbing results (e.g., "a rat burger"); could this discovery inform local produce and brand differentiation? Workshop beekeepers were worried about legacies of data that might have negative effects on their skills over time. These points raise questions about appropriate points to opt out of data gathering and what effects such opt-outs might have on a citizen science project.

Wider Insights. At the time of this writing, UK government law gives an individual the right to request closed circuit television (CCTV) footage of him or herself. The individual has to provide a specific date and time, proof of identity, a personal description, and must pay a fee of UK£10,[41] or approximately US$17. If the footage is not involved in a police investigation, it is then released. CCTV abuse has occurred as "operators spied on unsuspecting females," but CCTV has also solved countless breaches of the law.[42] An example of wearable technology that allows for opting out of monitoring is a project called CV Dazzle. To protect privacy, it "opposes the mainstream push toward the widespread adoption of face recognition" by causing personal appearance changes through digital interventions counteracting facial recognition software.[43] Harvey, the originator of CV Dazzle, also created apparel that masks the wearer's heat signature, counteracting heat-seeking technologies.[44] Who has, or should have, control over users' data, footprint, privacy and should monitoring technologies take a more remote or integrated position?

In 2013 Google launched "Google Glass," an augmented reality headset display where "glasses wearers can call up a variety of displays, such as GPS maps, the weekly weather, or sports results."[45] Through the display, users can call on a variety of situational information about artifacts, environments, and people. But how do viewees control what someone else can discover about them, when they are viewed through this technology?

41 GOV.UK, "Request CCTV Footage of Yourself," www.gov.uk/request-cctv-footage-of-yourself (accessed March 13, 2013).

42 Johnathan Duffy, "Something to Watch Over Us," http://news.bbc.co.uk/1/hi/uk/334853.stm (accessed May 5, 2013).

43 Adam Harvey, "CV Dazzle, Camouflage from Computer Vision," http://cvdazzle.com/ (accessed March 13, 2013).

44 Adam Harvey, "Stealth Wear, Designs for Counter Surveillance," http://ahprojects.com/projects/stealth-wear (accessed March 13, 2013).

45 Elizabeth Cohen, "The Eyes Have It: Google Glass and the Myth of Multitasking," http://blogs.scientificamerican.com/guest-blog/2013/03/13/the-eyes-have-it-google-glass-and-the-myth-of-multitasking/ (accessed March 13, 2013).

Drones, or unmanned aerial vehicles (UAVs), are increasingly used by the U.S. armed forces. The aircraft is remotely "operated by air force pilots, and flies 15 kilometres (approximately 9 miles) or more above ground."[46] These tools currently are actively used only by defence and law organizations, for either remote monitoring or situations where no human can enter. But "DIY Drones" has democratized the drone so that it can be used for personal use assembled by technically able people.[47] Although drones were not designed for citizen science, communities have benefited from them as, for example, environmental groups have mapped rain forests for signs of deforestation.[48] The American Civil Liberties Union advises that "rules must be put in place to ensure that we can enjoy the benefits of this new technology without bringing us closer to a 'surveillance society' in which our every move is monitored, tracked, recorded, and scrutinized by the government."[49] What is the legacy of all of this mapped data? Who owns it? Who is entitled to view it?

Motivations and Reciprocity

Workshop insights. During workshops the participants were motivated to create concepts as they were considering their personal needs. Other than the beekeepers, no participants thought that wider communities would be interested in their device concept, so they did not consider participatory motivations. Although many theories of "externalization" seek to explain the effects of public perception by peers in relation to volunteering,[50] this paper is more interested in reciprocity as motivation (i.e., all parties receive x for participating).

Wider insights. According to French sociologist Marcel Mauss, "[t]here are three main obligations: to give, receive and reciprocate."[51] Participants in citizen science activities give their time and potentially receive either accreditation or knowledge and reciprocation of gathered data. To conduct citizen science projects, frameworks are set up within which participants engage. These often volunteer particpants donate their time; for example, in Sussex, dog walkers and joggers are being recruited to monitor sheep while enjoying the countryside, with the motivation of caring for their environment.[52] It is not easy for users of data to "design and develop a citizen science project that meets the needs of all volunteers; indeed, such a catch-all approach is rarely useful."[53] Citizen science activities should be tailored to match the interests and skill sets of the participants: The most salient motivations are "enjoyment and enthusiasm for the common goals of the project."[54] Can you design projects for mutual reciprocity informed by participants' motivations?

46 Stephen Fortune, "Dronestagram," www.prote.in/feed/2012/11/dronestagram (accessed November 22, 2012).

47 Chris Anderson, "DIY DRONES," http://diydrones.com/ (accessed March 19, 2012).

48 Rhett A. Butler, "Model Airplane Used to Monitor Rainforests - Conservation Drones Take Flight," http://news.mongabay.com/2012/0223-conservation_drone.html (accessed March 13, 2013).

49 American Civil Liberties Union, "Domestic Drone," www.aclu.org/blog/tag/domestic-drones (accessed March 13, 2013).

50 E. Gil Clary and Mark Snyder, "The Motivations to Volunteer Theoretical and Practical Considerations," *Current Directions in Psychological Science* 8 (1999): 156-59.

51 Marcel Mauss, *The Gift: The form and Reason for Exchange in Archaic Societies,* (transcribed, New York and London: WW Norton, 1990), 7.

52 Michael Blencowe, "Part-time Shepherds Wanted," *Viva Lewes* 80 (2013): 19.

53 H. E. Roy, M.J.O. Popcock, C. D. Preston, D. B. Roy, and J. Savage, *Understanding Citizen Science and Environmental Monitoring* (London: Centre for Ecology & Hydrology, Natural Environment Research Council, 2012), 12.

54 Ibid., 11.

Studies have been conducted to understand the motivations and the "attitude" that drive citizen science participants, or the resulting behavior changes in the environment in which a citizen science project has taken place.[55] The negative side of monitoring is that accrued data cannot be seen in isolation. In addition, the unethical and dark side of citizen science must be acknowledged—for example, that malicious data could be used to "report on air quality from within a neighbourhood to drive down housing prices."[56]

As Mueller and Tippins state, "[a] participatory democracy must be interwoven with accessibility." Does collated data need review processes by approved collectives to ensure that data misinterpretations do not cause panic?[57] What data elements must be made accessible to motivate participants to participate? What are the effects on local insurance and house prices for example, and on illegal activities if all data streams are open? Can we design for mutual reciprocity without causing an adverse effect on a local economy or environment?

Where does safeguarding stop? For example, a child could buy and assemble an electronic kit for water monitoring that is installed in a rock pooling net. When the net and device are used on location, the device could feed back to a mobile device or to international biologists. What would the child get for this data? Would he or she accrue game points, or simply gain educational knowledge about the surrounding environment? If the child finds something negative, how do we interrogate an environment using citizens, making sure that we do not "unintentionally create a culture of fear"?[58] Could this monitoring system be considered a charitable donation, giving the child accreditation on his or her social network status?

Perceived Value

Workshop insights. During Workshops 1 and 2, participants did not consider third parties that could use the data collected from their device. None of them perceived that a third party would consider paying for the gathered data. Although participants did see the potential for quickly collating data in emergency situations (e.g., a flood), they did not foresee situations in which gathering data could prevent certain events (e.g., rainfall effecting floods). For example, if participants gave data access to a third party, could that in turn inform a wider community?

55 Dominique Brossard, Bruce Lewenstein, and Rick Bonney, "Scientific Knowledge and Attitude Change: The Impact of a Citizen Science Project," *International Journal of Science Education* 27 (2005):1099-121.

56 Eric Paulos, "Designing For Doubt: Citizen Science and the Challenge of Change," *Massachusetts Institute of Technology* (2009): 3.

57 Michael P. Mueller, Deborah Tippins, and Lynn A. Bryan, "The Future of Citizen Science," *Democracy and Education* 20 (2012): 2.

58 Eric Paulos, "Designing For Doubt": 4.

59 Emma Lunn, "Car Insurance 'Smartbox' that Could Lower Young Drivers' Premiums," www.guardian.co.uk/money/2011/apr/23/car-insurance-smartbox-young-drivers (accessed March 13, 2013).

Wider insights. Sensing and gathered data provides a wealth of information and value for commercial purposes. Sensing during day-to-day activities is becoming more commonplace. For example, devices are being used to lower car insurance premiums among young drivers through a "smartbox." The smartbox is a "pay how you drive" initiative, in which a device is installed in the user's car; and every 90 days, their payment package to the insurance provider is updated, depending on their driving.[59] The data accrued over time is interesting. Could users sell accrued data to automotive manufacturers for car fatigue or driver performance insights? Would data become increasingly valuable over the individual's entire life, or create revenue streams for participants?

Google is currently running "Screenwise," a data collection program using routers installed at participants' houses. Google pays people to participate—initially US$100 and then $20 every three months. "The Chrome extension will track what these people do around the web," including their activity on websites.[60] In the agreement notes, Google says that "data collected will not be personally identifiable," and it will "attempt" to remove identifiable data before sharing it.[61] Although the ethical and privacy issues are important, the fact that companies are perceiving value in people's collated data remains significant.

The Locker project is a start-up that "gives the owner the ability to control how [their data] protected and shared."[62] The start-up is trading on the momentum that "personal data could function as a kind of on-line currency."[63] The problem, notes Brustein, "is that companies don't need to pay for information when they can get it for free."[64] So as the abundance of personal data becomes a commodity for trade, are there other bodies of data than can be explored? Could future financial opportunities emerge for individuals conducting citizen science data gathering activities? Could these activities change over a longer period of time, and would they accrue more value? Jaron Lanier raises the question: "What kinds of jobs can survive in the new economy, the information economy?" Could this gathering of data make certain types of employment obsolete? Or could it add to it?[65] These revenue streams could be integrated into physical or armchair activities already familiar to participants.

Fishing in fresh water in the United Kingdom requires a rod licence that contributes to the health care of the waterways. The license gives the user "the right to use a fishing rod" for different fish categories, durations, and costs ranging up to UK £72 a year (approximately US $119).[66] Could initiatives—like fishing

60 Jolie O'Dell, "How Google is Collecting User Data and Paying Users for It, Too," venturebeat.com/2012/02/08/google-screenwise/ (accessed March 13, 2013).

61 Casey Johnson, "Google Paying Users to Track 100% of their Web Usage via Little Black Box," http://arstechnica.com/gadgets/2012/02/google-paying-users-to-track-100-of-their-web-usage-via-little-black-box/ (accessed March 12, 2013).

62 Shane Green, "A Container for Personal Data," http://lockerproject.org/ (accessed March 13, 2013).

63 Joshua Brustein, "Start-ups Seek To Help Users Put a Price On Their Personal Data," www.nytimes.com/2012/02/13/technology/start-ups-aim-to-help-users-put-a-price-on-their-personal-data.html?_r=0 (accessed March 13, 2013).

64 Joshua Brustein, "Start-ups Seek to Help Users Put a Price on Their Personal Data," www.nytimes.com/2012/02/13/technology/start-ups-aim-to-help-users-put-a-price-on-their-personal-data.html?_r=0 (accessed March 13, 2013).

65 Jaron Lanier, "The Online Utopia Doesn't Exist: We Need to Reboot," *Wired* (April, 2013): 73.

66 Environment Agency, "Fishing Licenses," www.environment-agency.gov.uk/homeandleisure/recreation/fishing/31497.aspx (accessed March 13, 2013).

licences—be transformed into devices that communicate data back to the environmental agency or another party? Could this data then inform local retailers or communities about successful products? For example, when a fish is caught, reciprocal information on location, weight, and species captured is of potential benefit to individuals who fish. The fishing community or club could also be interested in the data if its members wanted to replicate the conditions. A third party could use the collated data to monitor fish stocks, migratory patterns, health of the waterways, or biodiversity and to determine whether a location needs to be temporarily closed to avoid overfishing, all of which presents value in the lay user's gathering of data. "Fishbrain," a community smartphone app, catalogs catches, bait used, and location.[67] This app (at the time of this writing) has 9,717 members—a large uptake for recreational use, with no indication as yet of data use for citizen science. Could these applications polarize a situation and, rather than protecting wildlife, lead to over-fishing?

Trust

Workshop insights. Workshop beekeepers were concerned about making beehive locations known because they are expensive commodities that can be liable to vandalism. Workshop 1 participants created devices monitoring their children's location, verifying their safe arrival at school. They subsequently worried about other audiences' access to that data, either by security breach or when someone creates that device and surreptitiously places it on their child. Who would become responsible for this data: the parent, the school, or the service provider? How do you create mutual trust within an open system? Do you legislate against it? Or do designers of it become service providers that can restrict access to the product without approved input?

Wider insights. As studies of lead user activities have previously shown, the actions of professionals influence amateurs, which can filter into the mainstream. Public Laboratory of Open Technology and Science (PLOTS) make technological kits for scientists or laboratories. PLOTS offers a "community where you can learn how to investigate environmental concerns. Using inexpensive DIY techniques, we seek to change how people see the world in environmental, social, and political terms."[68] PLOTS are interested in democratizing pieces of scientific equipment that can be internationally downloaded or purchased as a kit. What interventions will be necessary for government bodies to trust this approach to research or subsequent data?

67 FishBrain, "FishBrain, Fishing Log, Fishing Reports: A Smartphone Application," www.fishbrain.com/ (accessed March 13, 2013).

68 The Public Laboratory for Open Technology and Science (PLOTS), http://publiclaboratory.org/home (accessed November 12, 2012).

Conclusion

This paper has explored the use of open design. Although we of course would not uncritically condone all applications of open design or open technology, we also note that open technology has advanced communities and developed tools for possible shared practice. The findings from workshops like the ones described are informing exporations in open design and citizen science that could emerge in design practice. As certain aspects of design practice and product creation become more democratized, these legacies and opportunities will arguably become more relevant and important. Open design systems at "a consumer level" are currently creating simple objects (e.g., Autodesk's 123D creature maker).[69] The parametric CAD system guides users through selections and form manipulations to create the creatures. As open hardware becomes more prolific, and as manufacturers use open design parts to create finished products, regulated kit construction is within reach. Kits can cater to niches, leading to monitoring tools that address charity or social issues for which funding has been restricted. The opportunity to combine the physical and the digital is becoming more integrated, and the when is foreseeable for lay users to make their own devices for personal or community needs. Who then has the right to dictate or regulate the outcomes or the "openness" that can prove so beneficial for socially and ethically aware design issues? The design process should not be dictated; neither should people live in fear. Open technology can certainly provide numerous positives. Although the insights from the workshops described are not final, they do serve as signposts that can be reviewed, ignored, or addressed. They point toward opportunities, nonetheless.

69 Autodesk 123D, "Make Your Own Creature Feature: Design and 3D Print Fantastic Characters Right from Your IPad," www.123dapp.com/creature (accessed March 13, 2013).