Gathering for Open Science Hardware 2018

Final Report: prepared for the Alfred P Sloan Foundation, Feb 2019

Executive Summary

Hardware forms a vital part of the scientific experimental process and the current supply chain limits access and impedes creativity and customization through high mark-ups and proprietary designs. Open source hardware addresses part of this problem through sharing open designs, which often take advantage of modern digital fabrication techniques. Expanding the reach of this approach within academic research, citizen science and education has potential to increase access to experimental tools and ease their customization and reuse while lowering costs. A growing number of people around the world are developing and using open source hardware in the context of the wider movement for Open Science, a trend we refer to in this proposal as Open Science Hardware (OScH). However, a coherent, self-organizing community is only just starting to emerge that could raise its profile and drive the social change within institutions that will increase uptake.

GOSH 2018 Meeting in Shenzhen, China

There is a full community report of the meeting available online:
http://openhardware.science/gosh-2018/

Recruitment of Participants

297 people applied to attend GOSH (double the number of 2017 applicants) and just over 120 were selected by the committee via an iterative process with multiple reviewers. The organisers looked for participants who were collectively approaching OScH from a diversity of perspectives and for people who demonstrated that they could be an asset and champion for the OScH movement including and beyond technology. In some cases this meant that people with policy, legal or fundraising experience received stronger consideration than people that had clear technical experience with OScH but tool developers were a crucial group of participants. Demographic goals were used to choose between different people with similar applications or where there was a split in opinion and were also used to prioritise travel grants.

The final 112 participants included:

- 37% women, trans or non-binary
- 55% person of colour or from a low income country
- 47% from NGOs or community groups

They came from 34 countries, despite visa issues resulting in many African participants withdrawing at late notice.

The Gathering

GOSH participants met over four days for discussions, workshops and unconferences around the theme “scaling hardware, growing community” with the goal of actioning the Global Open Science Hardware Roadmap to make open science hardware ubiquitous by 2025.

Science tools reaching more people for more purposes

Open Science Hardware is intended to ensure that more and more diverse people in more places can contribute to furthering scientific research, education and culture. During the meeting there were many sessions or practical workshops that represented this diversity and we are only able to provide a few examples here. In some cases hardware was designed to be low-cost and “hackable” for educational purposes. For example, Oliver Keller led a workshop building Muon Hunter particle detectors and discussed their use in education and citizen science. Other hardware is designed to make technology accessible where very few commercial options exist, such as the OpenDrop and DropBot digital microfluidics platforms, which move droplets of liquid with electrostatic forces. These can be adapted for a range of research uses and applications such as diagnostics.

Microscopes remain a fertile ground for innovation in the GOSH Community and in addition to the latest version of the 3D-printed, high precision OpenFlexure scope we saw the FluoPi from Isaac Nuñez and Tamara Matute, a chamber for imaging fluorescent bacteria that won the 2018 PLOS Open Source Toolkit Channel prize; the FlyPi from Andre Chagas designed for neuroscience experiments including optogenetics and the latest iteration of the Public Lab community microscope for analysing particulate pollution that can be used by their community of over 10,000 people interested in understanding and improving their environment.

Environmental monitoring and field research is a very active area. GOSH 2018 was introduced to digital naturalism by engineer Andrew Quitmeyer who led a workshop on the “field labs of the future”. A session on water quality monitoring highlighted many efforts in the US, Latin America and China using DIY and open source equipment for both academic and community-based science. All of these examples take advantage of at least some of open science hardware’s many potential benefits, for example being adaptable and customisable, locally manufacturable, lower-cost, easier to maintain and repair, increasing autonomy and building capabilities.

Advancing the GOSH Community Roadmap through learning, supporting and growing

Each of the first three days featured a new topic session on the three themes of the GOSH Roadmap: Learn, Support and Grow. These were continued through community-curated discussions and hands-on workshops. “Learn” took the form of a conversation on the ways in which open science hardware can enrich learning and how we can assess its impact. Initiatives from GOSH community members span from school science clubs and extracurricular activities

like those provided by Kharkana in Nepal and Litchee Lab in Shenzhen to professional training for early career researchers like the Advanced Labware Workshop held in Cape Town by TReND in Africa. There was recognition that education happens outside of the classroom in complex communities and that open science hardware enables students to identify and solve real world problems as evidenced by the TECNOx undergraduate competition in Latin America. However, the resulting learning outcomes can be harder to evidence and educational research is needed to address this issue.

“Support” covered ways in which the community can help each other in our work and gain external support and funding. Leonardo Sehn based at the Centro de Tecnologia Acadêmica, UFRGS in Brazil started the discussion by emphasizing the need for continuous and ongoing documentation in open source hardware development and ongoing technical and social efforts to improve this. Transparency and clarity in documentation helps in attracting Kickstarter funding, as confirmed by their Senior Design & Technology Outreach Lead Clarissa Redwine who also emphasised the importance of mobilising your community. On average, 30% of a Kickstarter project is funded by backers on the platform but 70% is funded by the proposer’s network. Finding the right community and ecosystem can therefore be vital and Violet Su next introduced x.factory, the Seeed Studios IoT Hardware enabler space that enables makers to go from idea to product by accessing the Shenzhen hardware ecosystem.

Ecosystem thinking preempted the “Grow” session that examined different routes to scaling. One route being explored by several of the >15 companies represented at GOSH 2018 is commercial manufacturing and distribution but we also discussed the need to increase the diversity, scale and impact of the OScH community in many ways and with respect to local differences. Chiu Chau of OpenTrons, who manufacture open hardware robots for pipetting liquids in laboratories, shared lessons from his entrepreneurial journey and possible avenues for financial sustainability and growth of open science hardware projects and organisations. He emphasised the need for passion, humility and determination but also community support. Returning to the theme of support for moving projects to scale, Jo-An Ho of the HAX hardware accelerator described their process of achieving success for their portfolio of companies and how one week of hardware development in Shenzhen is worth a month elsewhere due to the sheer concentration of goods and services in this vibrant city of technology.

Open Science Hardware in 2019: driving forward the GOSH Roadmap

Other themes that emerged during GOSH 2018 in the 40+ unconference session and workshops included the role of open science hardware in different regions and sectors, for example a session on “Boosting OScH in academic context: opportunities and challenges” that led to a write-up on PLOS. Going forward, the GOSH Community is evolving from convening around an annual Gathering and our online forum to a globally distributed network of events, activities, residencies and topic-based working groups and projects. This was reflected in the final stages of the event where participants documented 155 actions and pledges in line with the GOSH Roadmap recommendations and new ideas emerging from the community.

GOSH in Shenzhen

Outside of the internal meeting program, a major public event was held at x.factory attracting around 100 extra participants to hear talks about Open Science Hardware and view exhibits by GOSH attendees. We were also surprised by a third birthday cake presented to GOSH by Seeed Studios! Representatives from the GOSH organising committee attended the opening of the Shenzhen Maker Week, several participants presented and exhibited at Shenzhen Maker Faire and a half-day GOSH event featured eight talks and a panel discussion as part of the formal Maker Week programme, attracting over 150 attendees and featuring open science hardware on local news broadcasts.

Short residencies and co-working sessions were arranged at x.factory, SteamHead and Maker Bay in Hong Kong and time was set aside to visit Huaqiangbei Electronics Market and the HAX hardware accelerator.

Participant Evaluation

In summary, most participants indicated that networking and community building were the most valuable aspect of GOSH. The most requested sessions for future gatherings were hands-on workshops, unconference sessions, training workshops and open hack time. Roughly 30% of participants requested more evening or social events, open networking opportunities and more publicity for pre-GOSH activities. This year there were comments regarding session facilitators or moderators as having less training. Approximately 15% of participants mentioned inaccessibility of programming to non-native English speakers, or expressed concern over the lack of inclusion of local participant due to inadequate linguistic support. There was no considerable feedback to change the time allotment or structures of sessions- though roughly 20% of respondents identified pre-gathering organization as a possible means of allowing more depth and goal-based actions or objectives during the gathering. Several participants requested teleconference bridging with open-science community members who could not attend due to visa rejections.

Over 70% of participants launched a new project as a result of GOSH and 80% of participants connected with others as collaborator on an existing project. GOSH attendees were most excited by networking, commencing new projects and gaining new perspectives as a result of the gathering. In the future, participants hope to stay connected though in-person global and regional gatherings, the forum and website and roadmap activities. The importance of the GOSH Community and network arose as a theme throughout the survey.

Nearly 75% of participants gave their experience the highest possible ratings with 56% percent of participants noting that all of their expectations were met or surpassed. This year, there were fewer participants uncertain of what to expect during the gathering. 98% of participants would participate in another GOSH gathering in the future (with the remaining two percent indicating they would consider it). Respondents felt GOSH was most useful for networking, enhancing views on community development and expanding thoughts on equity, ethics, policy and legal considerations around OSH. At future GOSH gatherings, participants hope to see the topics of social ethics/ responsibility in open science and financial/ business modeling for open science,

addressed. Improvements that participants hope to see most in future GOSH meetings are delegating tasks and responsibilities to more participants, more balanced leadership, more emphasis placed on collective ownership of the event, more support and inclusion of new participants, better methods for collecting/summarizing/presenting the people and projects in attendance and extending the length of the event.

The full evaluation summary can be found here.

Progress Towards Metrics

The two metrics we had for this award included:

1) **A diverse set of at least 100 highly-engaged participants**

Just over 110 participants came to GOSH 2018 and as above they were diverse in terms of background and our demographic goals, although as per our experiences of organising two previous GOSH events, we feel that we could continue to do better in terms of participation by female, trans and non-binary attendees.

During the event, at least 50% of attendees were involved in facilitating, documenting or convening a workshop of unconference session and due to the highly interactive nature of the event almost all participants played an active role within those sessions.

Engagement has also been demonstrated after the event. Over 70% of participants launched a new project as a result of GOSH and 80% of participants connected with others as collaborators on an existing project. An example of some of the activities directly arising from attendance at GOSH include:

- Presentations about GOSH at UNESCO Latin America Assembly, University of Texas Austin, University of Oxford, Universidad Peruana Cayetano Heredia, SpotOn, Open Research London.
- Participants are involved in planning Africa OSH (April 2019) and Great Lakes GOSH (July 2019)
- Latin American GOSH participants successfully applied for a grant to run four open science hardware residencies 2019-2020 in Peru, Chile, Brazil and Argentina.
- Workshops have been held in Valdivia (Chile) oriented to environmental/water monitoring and on Open Hardware at the Freie Universität Berlin as part of international Open Access Week 2019.
- One attendee is now undertaking a four month internship on open source biology tools through connections made at GOSH.
- Dr Julian Stirling was embarking on a pilot project to look at the need for metrology (measurement and calibration) tools in the Global South when he attended GOSH and through contacts made has been able to visit Ghana, interact directly with a wide range of local producers and start applying for grants with new collaborators.

Additional future plans that lead on from GOSH 2018 include:

- Working on DIY microscopes for brewers to participate in a workshop for yeast management and microscopic quality control for brewers this March in Valdivia, Chile.
- Organizing a residence with OurSci in the Real Food Lab, which will be combined with the Great Lakes GOSH event. They will be running soils from RFLab to test models to predict soil quality using soil chromatography

2) **Online report detailing sessions plus slides, recordings, and other materials shared under open licenses**

During GOSH 2018, the documentation team recorded the event via photos, videos, illustrations and mapping of the community. An individual was assigned to do documentation at each session. This work has been compiled in the GOSH 2018 Community Report, which can be found at: http://openhardware.science/gosh-2018/

Lessons Learned During the Project

From GOSH 2018, we learned several lessons regarding logistics and organizing and the broader growth of the community. They included:

1) We picked a location that we initially assessed as medium-level difficulty for hosting an international event, especially with multiple local partners involved. We quickly were overcome with logistical complexities ranging from visa and bank transfer issues to issues communicating with lodging. It was essential that we had a pre-GOSH organizer meeting at the venue to sort through logistics and anticipate problems that attendees would encounter.
2) There is a challenge to balancing broadening participation with deepening community, both of which GOSH tries to accomplish. We had a significant number of newcomers to GOSH this year and the evaluation showed that returning participants were frustrated during several of the sessions because they wanted to build on conversations they had been having for some time versus starting from the beginning at where they left off in 2017. It will take some thought as to how to facilitate this dynamic in the future.
3) GOSH is at a critical moment in the scope and growth of the community. After three years of community building and hosting international gatherings, there is a need to think through larger issues of governance and leadership. This has been a complicated discussion to embark on because of the structuring of the community thus far, but we're hopeful that the resolution will enable GOSH to grow sustainably in multiple dimensions and maintain the community values that are core to what we do, particularly equity of participation and access.

Future Plans for GOSH

Coming up in 2019 is the second Africa Open Science and Hardware meeting in Dar es Salaam, Tanzania; a planned North America event in the Great Lakes region; technical residencies in Latin America; further community building in China plus work on **155 actions and pledges** to progress openness in research tools and make hardware a recognised and valuable component of open research practices.

GOSH has influenced other meetings and organisations outside of the science hardware space. For example the 2019 GOAT (Gathering for Open Ag Tech) conference, was based largely on the GOSH model and 12 organizations that came together there are now working on a grant proposal for integration of open source technologies in agriculture.

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Conclusion

The GOSH Community has been incredibly active between the 2017 and 2018 event. This is a clear indication that an international convening has been an effective catalyst for OScH. We are at a point in the history of OScH that we need to deliberately consider governance of the community so that it continues to grow as a movement.

We look forward to seeing the OScH community thrive, to implementing the Roadmap and the 155 corresponding actions and goals that the 2018 gathering participants outlined, and making open hardware ubiquitous by 2025. We are very grateful for the support of the Alfred P Sloan Foundation, whose support has made this project possible. Thank you.

Appendix 1: GOSH 2018 Media and Online Coverage

Journal articles citing GOSH

- Chagas, A. M. (2018). Haves and have nots must find a better way: The case for open scientific hardware. PLoS biology, 16(9), e3000014.
- Hsing, P. Y. (2018). Sustainable Innovation for Open Hardware and Open Science–Lessons from The Hardware Hacker. Journal of Open Hardware, 2(1).
- Pearce, J. (2018). Sponsored Libre Research Agreements to Create Free and Open Source Software and Hardware. Inventions, 3(3), 44.

- Pearce, J., Molloy, J., Kuznetsov, S., Dosemagen, S. (2019) Expanding Equitable Access to Experimental Research and STEM Education by Supporting Open Source Hardware Development. Journal of Open Hardware on Medium

- Oberloier, S., & Pearce, J. (2018). General design procedure for free and open-source hardware for scientific equipment. Designs, 2(1), 2.

- Smith, S., Land, K. J., Bezuidenhout, L., & Chagas, A. M. (2018). First advanced open labware workshop and rapid prototyping solutions for research challenges in Africa.

- van der Zee, T., & Reich, J. (2018). Open education science. AERA Open, 4(3), 2332858418787466.

Online Content

- PLOS Blog: Boosting Open Science Hardware in an academic context: opportunities and challenges
- Interview of GOSHer: https://zhuanlan.zhihu.com/p/48503334

Social Media

- Website: openhardware.science
- Twitter hashtag: #GOSH2018 and Community Account: @GOSHCOMMUNITY
- GOSH Community Flickr
- GOSH 2018 Forum
- Open FIESTA Wechat
- SDGo Wechat

Local Media Coverage

TV:

- Shenzhen News (October 14th, 2018)
- Shenzhen News (finance and economics channel)
- Maker TV (Oct 16th, 2018)
- SZTV (Oct 12th 2018)

Websites:

- China Daily
- Southern Metropolis Daily
- Shenzhen Evening News
- PhoenixNet
- Shenzhen Government Online
- Tencent News

- ZAKER (1)
- ZAKER (2)
- Shenzhen Industrial Design Industry Association

Newspapers:

- Shenzhen Evening News (October 15th, 2018)
- Shenzhen Special Zone Daily (October 15th, 2018)
- Guangzhou Daily October 16th, 2018)

Appendix 2: Full Schedule

Pre-GOSH

13:00 – Leave from hotel to visit Huaqiangbei Electronics Market
14:00 – 15:00 – Tour of HAX (near Huaqiangbei Market)
Independently organized events

Day 1 (Wednesday): LEARN

08:30 – 09:30 – Breakfast
09:30 – 10:15 – Introduction to GOSH 2018: organizers, Code of Conduct, history
10:15 – 11:15 – Speed Meeting – participants get to know each other
11:15 – 13:00 – Lunch + Tabling
13:00 – 14:00 – Topic session I: LEARN
14:00 – 14:30 – GOSH Roadmap, history and future (past discussions here and here)
14:30 – 16:00 – Unconference explanation, brainstorm, assigning sessions
— 10 minute break —
16:10 – 16:30 – Short facilitation training
16:30 – 17:15 – Unconference session (short 45m)
17:15 – 17:40 – Q&A, Open Discussion
19:00 – 23:00 – Organized social dinner, Kickstarter sponsored reception

Day 2 (Thursday): SUPPORT

08:00 – 09:00 – Breakfast
09:00 – 10:00 – Topic Session II: SUPPORT
10:00 – 11:10 – Unconference session
— 15 minute break —
11:25 – 12:35 – Unconference session
— Lunch —

13:35 – 15:00 – Unconference session
— 15 minute break —
15:15 – 16:40 – Unconference session
— 10 minute break —
16:50 – 17:30 – Q&A, Open Discussion
19:00 – Self-organized dinner

Day 3: (Friday): GROW

08:00 – 09:00 – Breakfast
09:00 – 10:00 – Topic Session III: GROW
10:00 – 11:10 – Unconference session
— 15 minute break —
11:25 – 12:35 – Unconference session
— Lunch —
13:35 – 15:00 – Unconference sessions
— 15 minute break —
15:15 – People w/ booths go to X Factory early
15:15 – 16:40 – Unconference sessions
16:40 – 17:30 – Everyone else travel to X factory
17:30 – 18:30 – X Factory reception + tour for GOSH participants
18:30 → 21:30 – Public Facing event at X-Factory. link for details

Day 4 (Saturday): ACTIONS

08:00 – 09:00 – Breakfast
09:00 – 10:10 – Unconference session
— 15 minute break —
10:25 – 11:35 – Unconference session
— 15 minute break —
11:50 – 13:00 – Unconference session
— Lunch —
14:00 – 15:00 – Topic Session IV: Actions / Roadmap
15:00 – 17:00 – How we move forward, update / adjust Roadmap
17:00 – 17:30 – Q&A, open discussion, wrap-up, group photo and goodbye!
17:30 – 18:30 – Open Floor