

Hackathons catch on for creativity, education, and networking

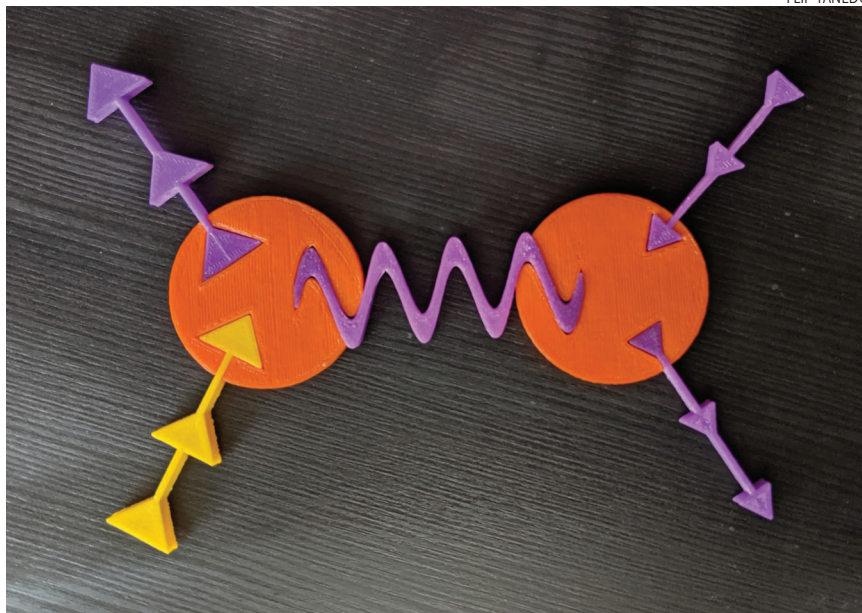
Physics and astronomy communities take a page from data-science and tech worlds to hold events of feverish teamwork.

In November 2019, 25 teams of students assembled at Argonne National Laboratory to take part in the CyberForce competition to defend and bolster energy infrastructure. An additional 79 teams met at nine other Department of Energy labs. The teams—consisting of four to six undergraduate and graduate students mostly in computer science and engineering—had eight hours to fend off cyberattacks by more experienced teams on simulated systems.

For DOE, the competition's aim is to build up the pipeline of future cybersecurity engineers for the energy industry. "It's wonderful to see the wow factor when things click for them," says Amanda Joyce, an Argonne cybersecurity expert who coordinates the annual competition. The lab has hired a handful of people through the event since it began five years ago.

David Hogg, a group leader for astronomical data at the Flatiron Institute and a physics professor at New York University, laments the typical format of scientific meetings: "All these amazing scientists from around the world are in the same location. But for most of the meeting, they sit quietly in their seats, not speaking to each other. That is the worst use of their time." Daniela Huppenkothen, an astronomer at the SRON Netherlands Institute for Space Research in Utrecht, shares that conviction. In 2014 she and Hogg joined some colleagues to launch Astro Hack Week. The annual five-day event brings 40–70 people together for tutorials and hacking. Scientists in other disciplines have created spin-offs, including Geo Hack Week and Neuro Hack Week.

At a well-run hackathon, says Huppenkothen, "there is a sense of energy and excitement. You take yourself out of your day-to-day routine and try to make progress on something else." Time scales are long in science, she continues. "The



SNAP-TOGETHER, 3D-printed Feynman diagrams got their start in 2017 at a public Science Hack Day in San Francisco, where Flip Tanedo (assistant professor of theoretical physics at the University of California, Riverside), Matt Bellis (associate professor of physics at Siena College), and Willow Hagen (a graduate student at Carnegie Mellon University) made prototypes. In search of a teaching tool, the hackers were inspired by Tinkertoy.

Astro Hack Week is very effective in reminding me of why science is exciting."

Hackathons come in many shapes and sizes, from traditional all-nighters to recurrent weekly gatherings. They can be run by civic groups, companies, or academic entities. The tasks may be focused or open-ended, and the balance of collaboration versus competition varies. Hacking events typically involve coding, but they can also focus on solving social problems, policymaking, or crafting. Nearly all consist of a burst of intense work on something outside the participants' usual activities. Common goals include working together, building community, and emerging with tangible outcomes. In the sciences, hackathons are often intentionally educational.

Pitch, hack, present

Many hackathons start with participants pitching ideas and perhaps stating their areas of expertise. The participants form teams and go to work; at the end, the teams present their results.

That's how the annual McGill University physics department hackathon works. The 24-hour event attracts high

school and college students. The only restriction is that projects have to be related to the physical sciences, says Nicholas Vieira, a master's student in astronomy who led the organizing team for the department's virtual event last fall. The organizers provide suggestions, like "develop a tool that could be used to teach introductory physics" or "make something that proves the Earth is not flat." Mentors are important for the hackathon, he says. They help when people are struggling to come up with ideas or as they work.

"The ability to work in a team and use your imagination is probably more useful for later graduate studies—and work in any field, really—than cranking out assignments," says Vieira. Among the projects that have come out of past McGill physics hackathons are a program that takes both route and elevation into account to minimize fuel usage for driving in a city and a web app that lets the user play with a magnetic pendulum. For in-person events, says Vieira, the organizers reserve space and provide food, and people can stay and hack through the night. In 2019, 150

FLIP TANEDO

people participated. The 2020 event was virtual due to COVID-19 and attracted 200 competitors.

At MIT's second annual quantum computing hackathon earlier this year, companies D-Wave and IonQ made their quantum computers available and offered tutorials on their technologies. "We had more than 200 participants in 29 countries across 12 time zones," says Madison Sutula, an MIT doctoral student in electrical engineering and computer science and co-organizer of the event. "The purpose is to introduce people to developing and running code on real quantum hardware," she says.

Quantum computing is in its infancy, and events like the MIT hackathon "help grow the workforce and spark new lines of inquiry," says Matthew Keesan, vice president for product development at IonQ. "Getting to write code that shoots lasers at individual ions [with the IonQ quantum computer] is cool. It's exciting." Among the winning projects this year were several games and a program that generated a song. "Prizes can be fun," he says, "but the camaraderie of a hackathon is the real reward."

Thousands of Microsoft employees take part in the company's annual hack week. That's far too many for everyone to pitch and present in person. Instead, ideas and teams are assembled online in advance. "One year I did a throwaway fun thing, related to visualizing air traffic in augmented reality," says Jonathan Fay, a software engineer at the company. "The next year I did a project in computer vision that dramatically sped up key calculations. It was an algorithm that eliminated entire classifications of false matches." The algorithm was based on an insight he hadn't had time to pursue, and it led to cost savings for the company, he says.

When people do passion projects, or just have the opportunity to do something different, Fay says, "their ability to focus and explore and enjoy is enhanced. That can be really effective."

The benefits of departing from routine cut across all forms of hackathons. At the 2010 winter meeting of the American Astronomical Society (AAS), James Davenport noticed sticky notes and scribbles on whiteboards accumulating around the conference center. They were for the Hack Together Day being planned for the last day of the meeting.



THE WINNING TEAM at the hybrid remote-on-site hackathon hosted last September by the University of Zambia used Twitter data to analyze whether people view COVID-19 as a hoax. From left, lecturer Habatwa Mweene, dean of natural sciences Onesmus Munyati, and the winning student team of Esther Mungalaba, Mudenda Sakala, Emmanuel Hansonga, and Clemens Chama.

"The guerrilla hype made it exciting and intriguing," he says.

The hack day itself was "transformative," says Davenport, who at the time was a second-year graduate student. "The mantra was 'do something, create something, learn something.'" People coded. But they also cut up their cloth posters and sewed tote bags and items of clothing. "The event had a radical bohemian attitude. For a graduate student, it was empowering," says Davenport, now a research assistant professor at the University of Washington and an organizer of the annual AAS Hack Together Day.

A close cousin of the hackathon is the sprint, where people dedicate several days to jointly explore data, such as from a particular mission or telescope. Ana Bonaca, a postdoc at the Center for Astrophysics | Harvard & Smithsonian, has been an organizer for sprints on data from *Gaia*, the European Space Agency observatory that is measuring precise positions and motions of nearly 2 billion stars. "The peer pressure and being held accountable is energizing," she says. Similar events have been organized around NASA's *Transiting Exoplanet Survey Satellite* and to prepare to analyze data related to dark matter and dark energy from the Vera C. Rubin Observatory.

At the Space Telescope Science Institute in Baltimore, Maryland, astronomer Erik Tollerud has co-organized a handful of in-house hackathons that paired software engineers with scientists to work on selected projects. "The scientists know what they want, and the engineers are better at writing and documenting code," says Tollerud. "The results were polished, published, and used."

Hacking for education

In the days leading up to Astro Hack Week every year, SRON's Huppenkothen has nightmares that no one stands up to pitch ideas. "But that never happens," she says. The event takes a broad approach to both topics and outcomes, and people end up working on apps, machine learning, websites, and more. The daily tutorials are largely guided by what the participants want to learn, and may involve data analysis techniques or machine learning. "Data science as a field is developing rapidly, and academia has been lagging," she says. "We use the tutorials and hacking as a vehicle to quickly expose people to new ideas."

Sergei Gleyzer, a high-energy experimentalist at the University of Alabama, has begun to incorporate hackathons into a machine learning class he teaches. "Each

task has a science driver, and each emphasizes a different aspect of machine learning,” he says. One task is to separate the Higgs boson signal from noise in simulated data from the Large Hadron Collider. Another is to predict the strength and shape of interactions between nuclear spins in an NMR spin-echo experiment. The problems are ones Gleyzer has posed in more traditional hackathons, but in the class setting students are given more time since they cannot free up their schedules just to hack.

Hackathons are a regular feature at LUT University in Lappeenranta, Finland, where students get course credit for them. As many as 10 hackathons a year are held, with participation ranging from 10 to 130 students. Usually they have a theme, often determined by local companies that “want to prepare a future workforce,” says Jari Porras, a professor of software engineering. Recent hot topics have included remote-controlled industrial locks, game development, and optimization of waste collection.

In the course of a hackathon, Porras says, teams produce a proof of concept. Some of the ideas have been taken into production, and students have taken jobs with the sponsoring companies. The companies also hold hackathons for each other as a means to seek subcontractors. For students, though, “we get technology companies to sponsor a hackathon, and the students learn content we don’t cover in traditional courses.” Through hackathons, he adds, “we are teaching teamwork, pitching, and presenting—all important soft skills.”

Nikhita Madhanpall is based in South Africa and runs educational hackathons for the Development in Africa with Radio Astronomy Big Data project. “The aim is to provide initial exposure to data science, with the hope to have an impact on socioeconomic development,” says Madhanpall. The hackathons focus on health, agriculture, and astronomy. Tutorials are provided, and because the participants are mostly novices, the challenges are specific. “We use a new data set and participants have to be creative,” she says.

In one event in Mozambique, the tutorial involved machine learning and image analysis related to Hurricane Maria, which devastated Puerto Rico in 2017. For the hacking part, participants put their new skills to use on satellite



MIT'S FIRST ANNUAL quantum computing hackathon in January 2020 drew 55 participants. This year, more than 900 people applied for 219 slots in the virtual event.

data to analyze flood effects from a local 2019 cyclone. For a 2020 hackathon, the University of Zambia hosted a mixed remote and on-site event. Participants got tutorials on how to gather, clean up, and use data from Twitter to perform sentiment analysis. They then were tasked with doing a Twitter-based project related to COVID-19.

“People in Africa are desperately hungry for knowledge about artificial intelligence and machine learning,” says Madhanpall. “They know about it and they don’t want to be left behind.” The main motivations are the skills and learning, she says. “But the prizes are important to drive everyone to work hard.” Past prizes, she says, have included hard drives, tablets, and subscriptions to online courses.

Diversifying tech fields

Siân Brooke is a fellow in computational social science at the London School of Economics and Political Science. For her PhD at Oxford University, she studied—and participated in—hackathons to explore how the culture of programming creates barriers to women entering tech fields. The hackathons were “dominated by young, socially awkward white men. They went to meet people like themselves,” says Brooke. “That reinforces who goes into tech. Hackathons need to make a good effort to encourage diversity. They should have a code of conduct, and they should show that they enforce it.”

Brooke dismisses the notion that emphasizing collaboration over competition is more attractive to female would-be participants. “We get chastised for being competitive,” she says, “but given the opportunity, women are incredibly competitive.”

The organizers of Astro Hack Week and some other events use algorithms to help select a diverse set of participants from the always large pool of applicants; last year Astro Hack Week was oversubscribed by nearly a factor of five. “We try to create a balance across discipline, geography, career stage, gender, and other categories,” says Huppenkothen. Another measure to make hackathons more inclusive is avoiding all-nighters, which may be seen as unsafe for women, are inconvenient for people with families, and are unpleasant for many people.

Some organizers have experimented with all-female hackathons. Neale Pickett, a Los Alamos National Laboratory scientist involved in DOE cybersecurity hackathons, has organized events for high school girls. Madhanpall is planning an all-female competition in Africa, where typically the applicant and participant pools are 20–30% female, she says. And the teams on the mixed-gender hackathons cannot have a woman alone with men on a team because, she says, “from experience, women find it easier to voice opinions or contribute when there are at least two women.”

Toni Feder