Designing 2030

Thinking and Doing with Data

DESIGNING 2030

The Concord Consortium

GORDON AND BETTY MOORE

WILLIAM K. BOWES, JR. FOUNDATION

This report is intended to be a faithful synthesis of the discussions that took place at *Designing 2030: Thinking & Doing with Data* held at the Gordon and Betty Moore Foundation in Palo Alto, California, on January 29 and 30, 2019. The goal of this report is to serve as a resource for those who attended as well as for others in the field. Throughout the report, participant comments have been paraphrased. The content and meaning of the ideas have been preserved.

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Foundation, other funding agencies, or individual meeting participants.

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Report on Thinking & Doing with Data

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Executive Summary

Data fluency is emerging as an essential part of modern education, not only for science, technology, engineering, and mathematics (STEM) in the U.S., but for every domain in a data-driven world. Our lives have become surrounded—often even governed—by data. Future learners will require experiences that help them explore, interrogate, and visualize data. They must become fluent with the production and use of data. To ensure equitable learning for tomorrow's leaders requires designing multiple opportunities to engage with data in meaningful learning activities, across grades and within systems of support. Yet without well-prepared teachers, access to powerful tools, nurturing communities, and a well-designed structure and system for guaranteeing opportunities to all, we stand to risk ingraining existing divisions or reinforce historical patterns of privilege.

The *Designing 2030: Thinking & Doing with Data* meeting held on January 29-30, 2019, catalyzed a group of education leaders to further advance the conversation on how to achieve data fluency and support data science education for all. Experts in science education, the learning sciences, and citizen science were charged with answering the central question: How can open data and innovative technologies transform the way we teach and learn science and broaden participation by more learners?

Five key themes emerged as actions the field must undertake to ensure data fluency on a broad scale:

1. Plant a firm foundation for data fluency education for all
2. Activate a critical mass of people who can empower others to be data fluent
3. Develop and embrace open-access tools and resources
4. Support community voices, data ethics, and data for social good
5. Foster interoperability and networking among programs, platforms, and organizations

The Concord Consortium is researching and developing innovative learning technologies to support deep and more impactful STEM learning. It convened a group of education leaders as a recognition that many more people—including technology developers, civic leaders, policy makers, teachers across the curriculum, and business experts—need to be involved in this conversation. Our collective goal is to empower every student to think, interact, and take action with data. Together the leaders worked to identify pressing needs and synergies that might be leveraged as engagement with data becomes central to future learning.

Section 1

Future Learning with Data

Introduction

Data are everywhere. From the minutiae of our everyday lives to the grand scale of global movements, our actions generate data, machines use data, and our decisions hinge on realizations derived from data. Smart manufacturing, robotics, conversational agents, transportation, and energy monitoring systems use data to operate systems. This trend is not only in academic realms of science, engineering, and computing, but has also moved rapidly into all aspects of society. Data-driven transportation, personalized medicine, environmental monitoring, and business intelligence all use data. Schools routinely use data to manage student records, track attendance, and assess student progress. Agencies are aggregating social and scientific data from multiple sources into massive online collections. Whether for future STEM workers or concerned citizens, the need to understand and work fluidly with data continues to increase at a striking rate. However, our capacity for working, learning, and thinking with data in the modern world has not kept pace.

Without some intervention, the life of data—beginning with the origins of data, how it flows through social and technical systems, how it is transformed to represent and communicate information, and how it is used in reasoning and for making consequential decisions—remains opaque to many. Today's elementary, middle, and high school students have very limited exposure to these topics and skills. Our future data scientists and data-fluent citizens are not equipped with the relevant preparation. Our essential educational design challenge is clear: ensuring learners and educators in and out of school gain the fluency they need to work within, understand, and live in a data-saturated society is one of the most crucial needs of our age.

Key Questions

Participants at the Designing 2030: Thinking & Doing with Data summit were asked collectively to answer these key questions:

- What kinds of experiences should school-aged learners have with data? How can learning resources and data tools be designed to further data-fluent learning?
- What must be done now and anticipated in the future in order to make data experiences both powerful and enduring?
- What knowledge, scaffolds, and trajectories are necessary to equip and empower tomorrow's professionals to access, understand, and make productive use of data?

Teaching and Learning Data Fluency

Schools present new possibilities for teaching data fluency within math, science, social studies, and computing classes, as well as across the curriculum with integrated, interdisciplinary projects. In math class, students encounter data when learning about statistics, means, medians, and variability. In science class, students can produce and make use of data when carrying out experiments with digital measurement and analysis tools.

When large datasets are available and combined with digital data analysis tools, thoughtful decisions about ways to select and manipulate data can be taught as "data moves" that transcend how math is typically taught (Erickson, Wilkerson, Finzer, & Reichsman, 2019). Inquiry and data together enable students to learn and engage in practices that are useful to help them pursue and answer questions beyond school exercises.

Consider, for example, students conducting historical trend research on marine food sources near ocean coastlines. Using GIS data tools and open datasets, groups of students can merge ocean temperature data, fishing rates, and fish migration patterns onto different regions of the map and begin to ask questions. This kind of research project bridges subject areas and encourages learners to get hands on with questions and information while introducing sources for data learning and supporting data science education at large.

Many out-of-school learning programs also offer rich and meaningful data experiences. Community and citizen science programs invite individuals, groups, and families to collect image and environmental data. Learners working side-by-side with scientists engage in the practices of science, from posing and revising questions to producing and understanding their data in the context of larger datasets and issues, as a growing and important contribution to scientific sense-making and the scientific enterprise.

Making and tinkering provide another motivating context in which learners can meaningfully connect to and engage with data. Hands-on opportunities with tactile, materials-based exploration can provide meaningful encounters in which learners construct and demonstrate understanding of data. Learners can use everyday materials like paper and low-cost electronics and components to turn craft projects into personally expressive, data-responsive objects like electronic data beacons that signal and display pollution levels and traffic congestion or share social media messages and personal stories.

The keystone for these engagements in and out of school resides in public datasets made available by agencies across sectors, including NASA, NOAA, EPA, USGS, U.S. Census, OpenData.gov, and more. These datasets present a clear opportunity for the education community to develop engaging, accessible scaffolds and onboarding activities for teaching and learning with data. Teachers and learners currently have access to tools for accessing and visualizing data. Combined with sequences of instructional activities, gentle on-ramps to learning with data can create meaningful teaching and learning experiences at introductory and advanced levels. Together, these communities and instructional resources offer opportunities for multiple learning pathways to data fluency.

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Data can help us see new ways of understanding the world.

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Section 2

Demonstrations

Twenty-five thought leaders gathered in Palo Alto, California, at the Gordon and Betty Moore Foundation for *Designing 2030: Thinking and Doing with Data* to build common understanding across projects, program interests, and visions for learning with data. This group was comprised of participants from education organizations, community-based organizations, universities, and science institutions. Social networking in small groups built connections between participants. To further surface connections of the collective expertise in the room, and to begin to establish common language for data science literacy, the meeting began with facilitated technology demonstrations of different data-rich learning experiences created by the participants.

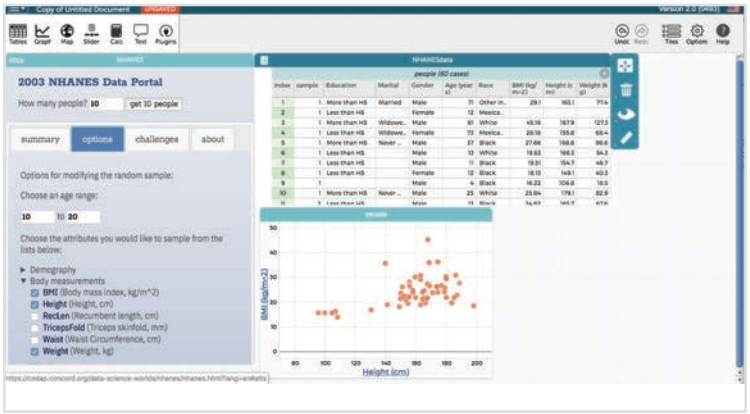
CODAP: Data Moves

A way of thinking about what happens when students do data science

Presenters
William Finzer and Michelle Wilkerson

The transformation of data from one form to another is the job of analysts and data scientists. Working with data by joining datasets, merging, eliminating unwanted data, and ordering data are just some of the transformations called "data moves". A data move is "an action that alters a dataset's contents or structure" to enable different questions to be asked of the data (p. 3., Erickson et al., 2019). The Common Online Data Analysis Platform (CODAP), an open-source software package for dynamically exploring and learning with data, allows users to easily perform a wide variety of data moves. This demonstration, using data from the National Health and Nutrition Examination Survey (NHANES), was based on work done by Tim Erickson and Michelle Wilkerson as part of the Concord Consortium's Data Science Games project.[1]

codap.concord.org



- Summarizing
- Sorting
- Calculating
- Making a hierarchy
- Merging
- Filtering
- Grouping
- Stacking
- Joining

[1] This material is based on work supported by the National Science Foundation under Grant Nos. IIS-1530578 and DRL-1435470.

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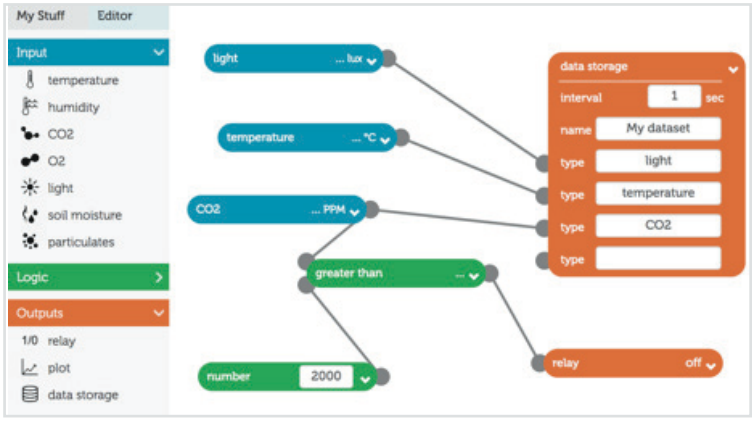
Dataflow

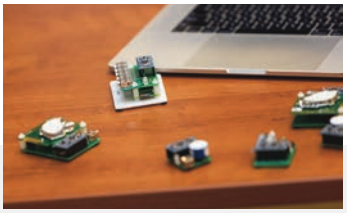
Internet-of-things devices for data production in science

Presenters
Lisa Hardy, Sherry Hsi, and Colin Dixon

Scientists and engineers build and use instruments to control, measure, and collect data about scientific phenomena as part of their practice. Data is also changing how biology is studied in classrooms. For example, long-term ecological experiments can be set up on classroom desktops to explore and monitor gas exchanges, cellular respiration, and biotic factors in an eco chamber with plants. Designed specifically to engage students in authentic science practices, Dataflow is open-source software that pairs with with low-cost Internet-of-Things sensor kits to provide learners authentic tools for designing their own data-rich experiments. Using this kit, learners can use computational tools to design and control experiments from biological phenomena and explore the data they produce.[2]

concord.org/dataflow





SPOTLIGHT

Data Literacy for Teachers

The growing importance of education data at all levels has given rise to calls for improving how teachers use data from school systems, student performance, and student work to make instructional decisions. The focus here is on better preparing teachers for working with data and data-driven decision making. These efforts are aimed at improving teachers' ability to understand data for their instructional purposes or "data literacy for teachers" (Mandinach & Grummer, 2016).

While such efforts improve teachers' ability to understand data for their instructional purposes, they generally do not include attempts to improve teachers' understanding around supporting and teaching data fluency to learners. Education data for teachers is quite distinct from the learner-focused efforts described in this report as data fluency education. Teachers will also need pedagogical content knowledge specific to teaching a domain, representational fluency, and other know-how to be able to support data experiences effectively for learners.

[2] This material is based upon work supported by the National Science Foundation under Grant No. DRL-1640054.

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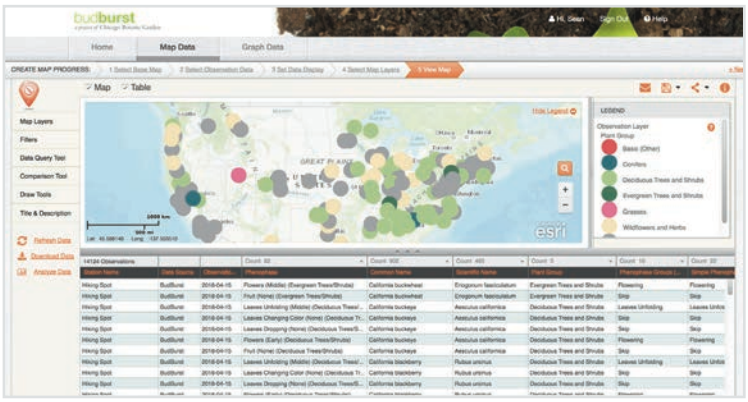
FieldScope

The power of citizen science

Presenters
Daniel Edelson and Emily Harris

Observations and data contributed by citizens can help scientists build more robust models, make better claims, and reach stronger conclusions. FieldScope is an interactive platform for citizen scientists of all ages and backgrounds. Organizers of field studies can leverage sophisticated graphing and mapping visualization tools and resources to enhance their existing and future citizen science projects. FieldScope enables participants to conveniently upload measurements, observations, and media to a shared project database. Used by two national projects, BudBurst and FrogWatch USA, as well as regional projects to map species and watersheds, FieldScope is designed with special features to support use in educational settings.



www.fieldscope.org

SPOTLIGHT
Data Visualization

Artists, computer scientists, educators, journalists, climate scientists, and museums use data visualizations to communicate science to different audiences including the general public. Data visualizations can also be viewed as a medium that can be explored, interrogated, and transformed into different expressive representations. A body of research from cognitive psychology, science education, and the learning sciences has informed how students learn from and through data visualizations. From using multiple representations as reasoning tools to using visualizations effectively, future learners and teachers will need support to fully use data visualization processes including ways to map attribute values of data to representational forms.

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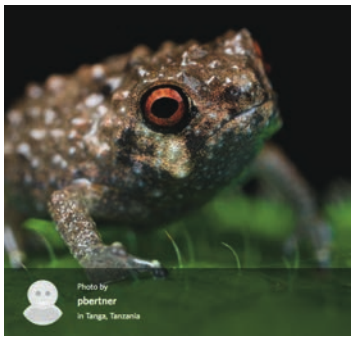
iNaturalist

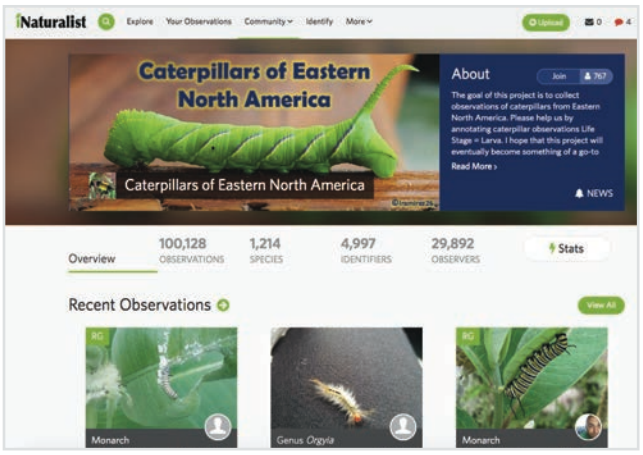
Connect with nature and generate biodiversity data

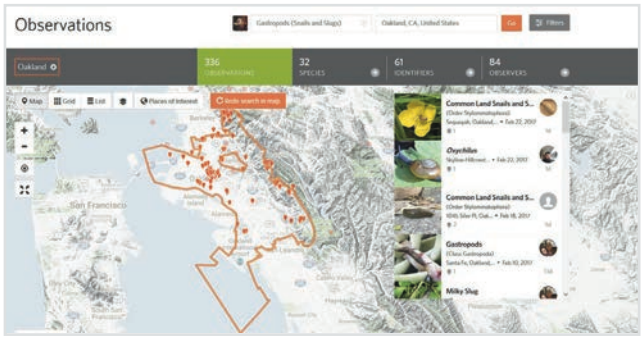
Presenter
Scott Loarie

iNaturalist is an online social network of people sharing biodiversity information to help each other learn about nature. It is also a crowdsourced species identification system and an organism occurrence recording tool. Users can record observations, share photographs of nature in context, get help with identifications, collaborate with others to collect biodiversity data for a common purpose, or access the observational data collected by a global community of naturalists.

www.inaturalist.org







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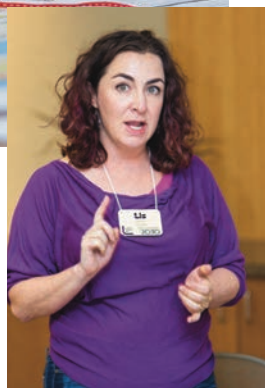
Open Data, Open Minds

Paper, electronics, and local data stories

Presenters
David Cole and Elisabeth Sylvan

Data is useful only when it has a story to tell. Open Data, Open Minds explores the possibilities of connected learning, fabrication, open data, and civic engagement, using paper and electronics as a GUI and display for data. With "low-resolution data"—selected data points or observations drawn from research and rendered on paper with light and simple outputs, such as motion or sound—expressive projects built with paper and electronics offer accessible, introductory data experiences that complement the computational breadth and depth available in a data visualization on screen. Open Data/Open Minds supports learners and their communities in the creation of local data stories using science journaling, crafted visualization, and data investigation. This demonstration shared a pop-up paper project—a city data dashboard for Austin, TX—assembled with LEDs, servo, and an Adafruit Feather tethered to a phone, displaying real-time temperature, particulate levels, traffic volumes, and time of day.

nexmap.org/open-data-open-minds



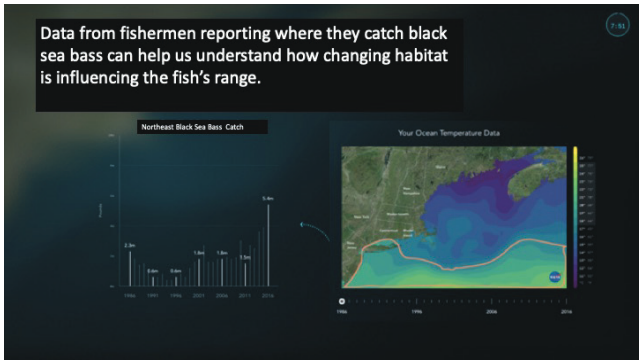
SPOTLIGHT
Personal Data

Networked devices have the ability to track data about an individual. Different pieces of information contributed by the individual or gleaned by stealth from devices installed in civic infrastructure are data. Health records, personal fitness trackers, faces on social media, school grades, online shopping behaviors, electronic bus passes, or other data can all identify individuals. Activities around one's personal data might be a self-mirror to help motivate and interest learners in working with data. At the same time, these could also be used to teach and prepare learners about data privacy, security, and the dark side of data.

Vital Signs

Engaging students with scientists and data

Presenter
Leigh Peake



The Gulf of Maine Research Institute's citizen science program, Vital Signs, launched in 2009 through a collaboration of scientists and middle school teachers. Vital Signs aims to support novices in producing ecosystem data of value to scientists while simultaneously achieving classroom learning outcomes. Investigations developed with Manomet scientist Dr. Marissa McMahan focus on climate change questions, such as "Is the proportion of native crabs versus invasive crabs changing over time and in response to warming temperatures?" Students use a transect and random quadrat method to record crab abundance for multiple species as well as individual measures for each crab. In the classroom, students use multiple sources of data (their data, the Vital Signs database, the scientists' data, climate data) to address the original research question. Since 2009, over 180 teachers have engaged 7,500 student teams in contributing over 10,000 data points to investigations by 60 scientists.

SPOTLIGHT
Community Data

Community members make everyday observations of data and share them with others online. Whether a single photograph, a text message, a note, or a measurement, individual bits of data contributed by thousands of people globally can help fill in missing information gaps, monitor conditions, validate findings, and help with new discoveries. The question of who shares and owns community-contributed data remains an open question.

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Data are everywhere.
Except in classrooms.

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Section 3

World Café Conversations about Data

Conversation Starters

- By 2030, what do we want young people to be learning about data? What do we want them to be able to do?
- What kinds of stories - what kinds of storytelling - will be important? What should storytelling look like in science?
- What tools do young people need to be able to tell their own stories with data?
- What learning experiences and practices are missing now that young people need to prepare for the future?

Colin Dixon from the Concord Consortium and Emily Harris from BSCS Science Learning facilitated three structured conversations to engage participants in different perspectives on data.

Conversation 1: Data as a Medium

We tell stories. Data of some kind have always been a part of the stories we tell. But now, we can tell stories with new kinds of data, in new ways. We are teaching young people to tell stories with data and these efforts are critical: children and youth must understand data as more than isolated bits. They can use data as a medium that is enmeshed in lived experiences. Data is used to visualize and represent their own stories to further shift their experiences, values, and dreams.

Stories are also told about us. In school, students' stories have always made use of data: grades, race, income, absences. Now, data ecosystems are becoming larger and more pervasive. And yet, to the learner, the stories these data tell are often unseen, even while they become more durable, more powerful, and for some, more dangerous. Data are telling stories in ways that young people don't realize, understand, or have a say in.

Where do these kinds of data stories merge? Already, we see young people curating and hacking data streams, tracking aspects of their lives that they think are important. Student portfolios integrate media, code, datasets, and reflection beyond single grades. Young people produce data about the places they go, the air they breathe (using sensors), and the issues they care about. More than source material, these data are a medium. The data young people produce - and the ways they act with it - become part of their trace in the world, part of their narrative. What should this mean for education?

Conversation Highlights

Theme: Learner-centered, inquiry-oriented experiences

- Data can serve as a foundation to make a story valid and valued.
- It is important to help kids get beyond making data into an infographic.
- There is a tension between data as evidence and data as a starting point — between knowing how to represent your data in a way that reflects your values and expresses what you intend, and, on the other hand, data discovery, in which you are surprised by what you find and taught how to interrogate the data.
- There is a lot of data that lives on a mobile phone or could be collected by one. A story can emerge from the data recording, use, and questions that arise.
- Separating data out from content and perspective is false.

Theme: Working with data as expressive and fluid

- Artists work in a medium. A medium is malleable and shapeable. Media can be deconstructed and reconstructed.
- Wood, paper, paint, and fabric are examples of different media in the arts. Conceiving of data as a medium implies that learners work with it, transforming, displaying, and using it for a purpose.
- When considering data fluidity, data can supply a starting point, act as a malleable medium, stand as a source of evidence, and act as a Petri dish to be examined.
- Multiple stories can emerge from one dataset.

Theme: Making data meaningful

- The meaning and value of data are defined by its use.
- Important patterns in our lives go unnoticed until they are represented in a way that makes the patterns apparent. Knowing how to represent data is essential. Data representations are tools for thinking, not merely outputs of thinking
- How are infographics treating data like a medium? What is the role of qualitative data?
- Messy data combined with messy data tasks produce compelling stories—stories people care about.
- Working with data is like making an article of clothing: in working with data, you impose a structure on the medium, construct and reconstruct the pieces, and treat data as the fabric. The process is just like taking apart a dress for the re-use of its elements.
- What is the relationship between these characterizations of data and traditional ecological knowledge/ cultural practices? We may not turn everything into data, but working with the verbs around data provides useful ways to think about observations in the world.

Conversation 2: Making Data as Making

Powerful learning environments have powerful cultures. For example, recent interest in "maker-oriented education" is driven in part by the potential makerspaces have to invite new forms of participation and interaction. Key aspects include:

- *Contribution*: Learning and making things is public and social.
- *Responsive*: Making is personal, but also shareable and often community-driven.
- *Open*: Tools span digital and physical, expert and novice. Mentors both give and seek help.
- *Surprising*: Encounters with sticking points and messiness lead to new kinds of learning.

Conversation Starters

- What culture of data do we want to see in 2030?
- What kinds of interactions and communities do we want students to have when learning and working with data?
- What should we do to help learners collaborate more with peers, scientists, and mentors?
- What other values, supports, and connections are important?

In fan literature, youth media, and other "participatory cultures," youth voices are a non-negotiable part of the design. Moreover, personal histories and geographies are valued and shape the story. How does culture take shape, especially within educational settings?

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Conversation Highlights

Theme: Communities matter

- Making and makers of data can open participation and collaboration.
- Making involves apprenticeship learning — helping others, mentoring, learning from failure. We should foster these in data-making experiences also.
- One can imagine kids immersed in communities where deciding when, where, and how to make data is the norm and a regular part of youth experience, such that youth are not there only to collect or record data.
- Youth make their experiences with scaffolding and support.

Theme: Invitation to all

- Making provides sources of insight and invites learners into a process.
- Youth need ownership. Owning the data is key to youth involvement.
- Everyone has the potential to engage with data.
- Open community spaces, like makerspaces, might seem inviting because people come assuming they will get to make something. However, the reality of this promise depends on who is there.
- Do makerspaces have a culture of fostering understanding, support, and agency; are they accessible and equitable to everyone? How can data-oriented spaces better support these cultural needs?
- Part of learning and education will need to involve discussion of what it means to be fair, the ethics of data, data bias, data interpretations, how data will be used, for whom, etc. What is the culture of fairness in analysis and interpretation?
- Teaching students practices and values such as peer review is important.
- Is adding storytelling to data work simply "putting chocolate on broccoli" to make it taste good? We need to make ways of engaging with data legitimate and valued.

Theme: Designed systems need to reflect core values

- In the ideal world, data systems are interoperable.
- Transparency in how systems (political, social, technical) use data provides empowerment to youth. Black boxes lock makers out.
- Makers use and embrace open licensing.
- "Making" creates an imperative to work and create for change.
- Data can be used for problem solving and advocacy, but algorithms, analysis, and instruments that produce data contain hidden assumptions.
- How do we balance giving kids "clean data" or projects that result in a doable product versus something messier with an unknown outcome? When is it acceptable to have a good process, but no product at the end?

Conversation 3: Data Violence and Afterlife

Data can do things in places where they weren't collected across time and space, posing potential dangers. Some have termed these dangers "data violence." A California state database of "gang" members contained at least 42 babies. A Black developer discovered in 2015 that Google's photo recognition software had tagged pictures of him and his friends as gorillas. Facebook auto-suspended Native Americans for using their real names in that same year. Facial recognition software struggled to read darker faces in 2016. Software in airport body scanners has flagged transgender bodies as threats.

Conversation Starters

- Who owns data and what should data's lifespan be? How can we build in life support or ensure data's proper demise?
- In what ways do we imagine data being able to expand the worlds across which young people travel?
- What codes of ethics or behavior need to be shared and written around data? What social, economic, and environmental issues will data bring young people into contact with?
- How might data link together organizations, institutions, or settings across a learning ecology?

Just like physical violence in the real world, such "data violence" occurs as the result of choices that implicitly and explicitly lead to harmful or even fatal outcomes (Hoffman, 2018). Data is subject to the same forces—the same biases, assumptions, economics, and inequities—that shape the rest of society. Data can mitigate or exaggerate the power of these forces.

Yet data can also have an afterlife, taking stories and people into new perspectives. In this afterlife, stories are confronted, but also amplified. Data can be tools for not just individual, but social, organizational—and even educational—change. The afterlife of data can have a different future. Data can be reborn.

Conversation Highlights

Theme: Power and control of data

- What are the dimensions of data openness or closedness?
- Data violence is proof that data matter. This creates learning opportunities. Righteous indignation can be a motivator. Kids are smart; they don't want to get played.
- Are these cultural extenders or reifiers? Data could amplify a power imbalance.
- If we make or provide data kits or tools, are they democratizing? Or are they more akin to the phenomenon of "canalization" in science, in which the state of a system or organization goes downhill in a manner that guides a feature such as a biological phenotype down a narrow pathway?
- Should data become public property? There is value in transparency of data, e.g., in updating without

Theme: Uses, misuses, and life of data

- Values-based systems and microcommunities matter. Data persistence can become a serious concern as data becomes decontextualized over time. Related to data ownership, what or who gets to decide how data live on or become reborn?
- We don't know how data will be used in the future. How do we not become paralyzed by hypothetical future uses?
- How does informed consent intersect with new types, uses, or availabilities of data and their unknown futures?
- Stories (and data stories) exist at a moment in time, yet they may be rewritten.
- Data violence points to the failings of AI: bias in algorithms and training sets. Again, the work of the Algorithmic Justice League might offer some patterns to follow.
- It is hard to imagine how data can mitigate, not simply exaggerate, claims, when data can be used to support multiple arguments.
- Data about education/educational assessments could lead to the wrong conclusions. The principle of "garbage in, garbage out" applies here, as well as the recognition that we measure what's easy to measure, not necessarily what's meaningful.

Theme: Pro-social policies and educational practices

- Can we foster "targeted messiness"? How do we foster this as a shared value? When should we embrace data's messy nature? When should we offer assistance?
- Because data are often entangled in an experience, how do we support the learning of content as well as the practices and values of working with data?
- What might affirmative action for data fluency look like? Can we develop systems and access so we don't need these kinds of policies?
- Ethics should be part of the school curriculum. Scientists also need to be trained in these concepts and concerns.
- Beyond mere access to data, we could provide a host of other resources, including on-ramps, mentors, communities, and more.

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Data literacy was 20th century.
Data fluency is now.

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Section 4

Keynotes: Data Connections: Context and Community

To complement the breakout and working group sessions, *Designing 2030: Thinking & Doing with Data* included talks from three speakers—Chad Dorsey, the Concord Consortium; Shannon Dosemagen, Public Lab; and Lissa Soep, YR Media—who offered distinct and compelling visions for why it is an urgent, opportune time to engage creatively and proactively with the proliferation of data in our lives.

KEYNOTE 1

Messy Data Futures: Call for a Messy Data Coalition

Chad Dorsey, The Concord Consortium

Pattern recognition and the ability to identify categories, themes, and priorities, is central to the idea of data fluency and the critical, higher-order thinking that underpins effective science education. There are important patterns in our lives that we may not notice until we are able to represent them. To make this point, Chad Dorsey shared a future scenario of what a fourth grader today would need to be prepared for a future with data.

He argued that today's students will need to be not just data literate, but fully data fluent if they are to navigate capably a world of data tools and data experiences. He made the case that, thanks to the proliferation of information, the capabilities and inconsistencies in machine learning, and the characteristic variability in datasets, everyone, from someone learning to use a computer for the first time to a college graduate trying to understand AI-enabled appliances, is going to be engaged with what it means to be an informed citizen in a data-driven future.

Teaching and learning with data will lead us to think beyond spreadsheet calculations towards practices and habits of mind that support a collective ability to question, to develop and refine problem statements, and to identify protocols for gathering and reviewing information, so we can use data to prioritize and synthesize information effectively. For context, Chad offered an arresting visualization: five years ago, there were more digital data bits than stars in the universe.

Going forward, we will be teaching and learning with unprecedented quantities of and access to data. The Concord Consortium proposes that this world of "messy data," defined by unknown or variable conditions in our datasets, by data-driven visualizations, open data repositories, and infographics represents a baseline for engagement. Messy data is a term the Concord Consortium uses as a pedagogical context for thinking of data as learning material—and it's a call to action Chad shared with the group, inviting practitioners and community members to join the Messy Data Coalition because data are everywhere, except in the classroom.

KEYNOTE 2

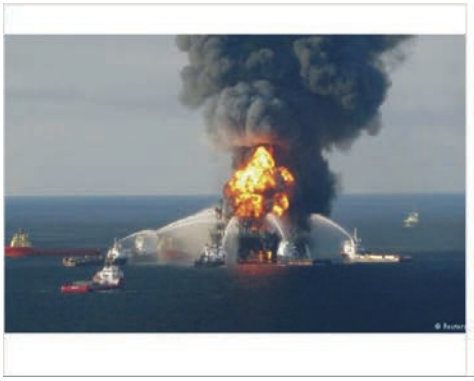
Collaboration in Action: Community-driven Projects for Environmental Problem-Solving

Shannon Dosemagen, Public Lab

Growing up in the New Orleans area, Shannon Dosemagen experienced the BP oil spill firsthand. She shared how this event in 2010 prompted her to organize communities to participate in environmental monitoring and activism, using low-cost DIY tools and technologies to collect and share data about the spill and its impact. This began the work of Public Lab and provides a continued blueprint for its commitment to democratize science to address environmental issues that affect people and communities.

In response to the spill a group of concerned residents, environmental advocates, designers, and social scientists lofted "community satellites" made from balloons, kites, and digital cameras to collect real-time data about the spill. Local citizens collected over 100,000 aerial images, and contributors used an open-source platform to stitch these image files into maps of the coastline before, during, and after the oil had spread. These high-resolution maps were featured by the BBC and the *New York Times*, among others, and allowed residents to have a direct voice in the unfolding story about what was occurring in the Gulf Coast. This approach to civic engagement, science learning, and data activism is at the heart of Public Lab's mission.

For Public Lab, research questions are local questions. This operating principle reflects the organization's commitment to the idea that the way to get at the issues, conditions, and rules in big data inventories is to focus on the people and places this data effects most directly. To borrow a phrase from the Finnish education researcher Pasi Sahlberg, the key to deep learning is to stop scanning big data metrics and start looking closely at what he calls "small data." Public Lab makes good on this approach in its faith in people and their experience, and its commitment to providing tools for communities to engage with local data.



Public Lab operates against a backdrop that encompasses open government, civic engagement, civic technology, crisis mapping, citizen science, and new media production for journalism and advocacy. Its work is built around local collaborations and connections with a methodology that asks questions, tests open-source hardware and software for gathering information and maintaining systems, interprets processes and procedures, and draws conclusions to support advocacy. To do this they engage a community of experts and practitioners that typically include educators, web developers, scientists, and community organizers.

At the end of her talk, Shannon described what Public Lab has learned as it has built trust and understanding through data and science learning. Her recommendations read like a roadmap for the best kind of invention, collaboration, community-building, and research:

1. Engage researchers, not subjects
2. Pull complexity off the shelf; modify minimally
3. Build in openness and accountability
4. Create collaborative workflows
5. Maintain public data archives
6. Mainstream true accountability
7. Let images communicate complexity
8. Protect openness with viral licensing
9. Create locally

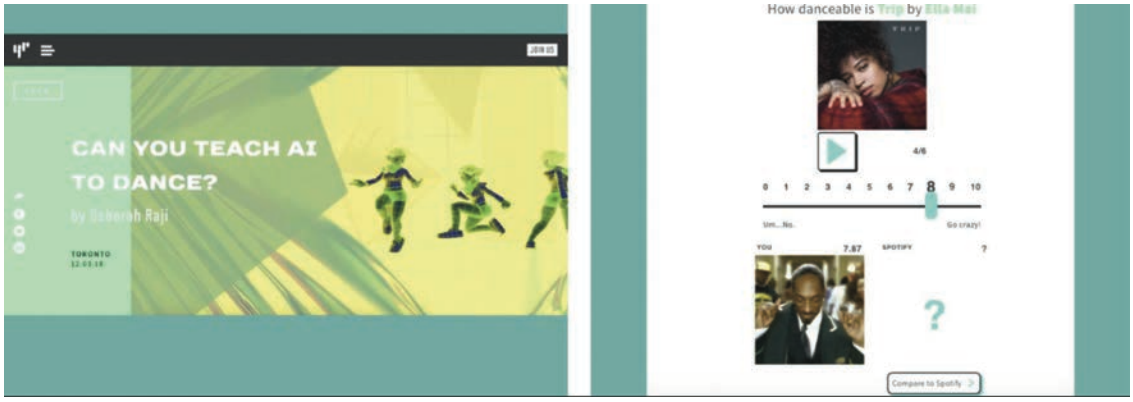
KEYNOTE 3

Code for What? From Data Journalism to Critical Computational Imagination

Lissa Soep, YR Media

As the founding director for YR Media, Lissa Soep and her colleague Clifford Lee advocate for civic imagination and participation through youth-led media storytelling with data. Lissa introduced her talk with an essential question, "Code for What?," inviting consideration of the intention behind the programming and the algorithms that are shaping so much of what we find and consume online.

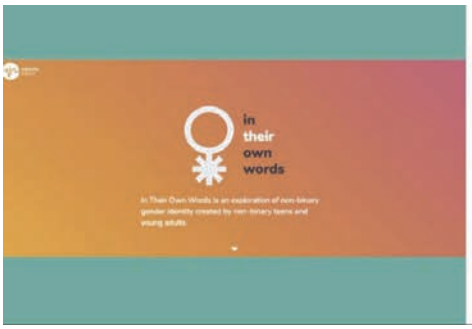
YR Media, formerly Youth Radio, has been a groundbreaking organization in its focus on civically engaged, interest-driven, production-centered learning and community building. In a series of inspiring demonstration projects, Lissa shared examples of YR Media's approach to youth engagement and media production in response to complex and increasingly prevalent technologies such as AI. Notably, YR's approach is not solely about problem-solving per se; rather, it's about mindset, engagement, and world-building—using the information markers, public APIs, and youth culture's fluency with media to create data-driven narratives that instruct and engage through story and experience.

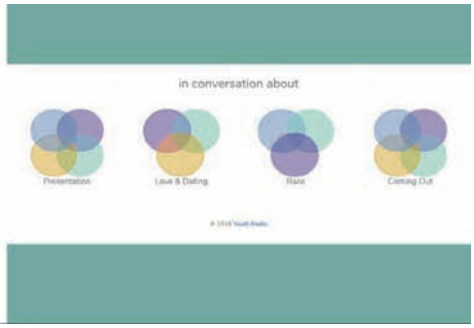


In a compelling example, "Can You Teach AI to Dance?," which analyzed the danceability of tracks on Spotify playlists, Lissa shared how YR Media's production team tapped youth interest and expertise with music to develop a lens for thinking about the contours and conditions in the rules and metadata contained in playlists. This unique line of inquiry also tells a story about the information and network systems we use on a daily basis, leading to natural questions: How does one build a soundtrack? Who is creating this music and media? What does it mean to teach a machine to assemble media with such immediate and emotional appeal?

In a second example, "In Their Own Words," an exploration of non-binary gender identity created by non-binary teens and young adults, YR Media turned to the subject of journalistic principles, archival stories, and questions about who owns data. Data exploration in sensitive contexts creates space for teens and young adults to explore the dynamics and boundaries of community conversations. This in turn raises questions about data and power: Who owns and controls access to this kind of information? What are the rules and rituals we use in conversation? How should we build community in these contexts?

Lissa left us with was the powerful idea that if data is persistent—if it has a design and an afterlife—then what continues and is interoperable in our data culture are our exchanges, the community-building, and the space for imagination that we can build together.





SPOTLIGHT

AI & Machine Learning

In 2011, a computer won the television game show Jeopardy against a human. This was made possible not by a sophisticated computer algorithm, but with an artificially intelligent engine fueled by and trained with data from multiple sources. Three years later, virtual assistants with natural language interfaces are found in smart phones and new home appliances. Machine learning was a course relegated to budding computer scientists, but is now part of general technology literacy to understand how robo assistants work, how data is used in automation, and the relationship between humans and data.

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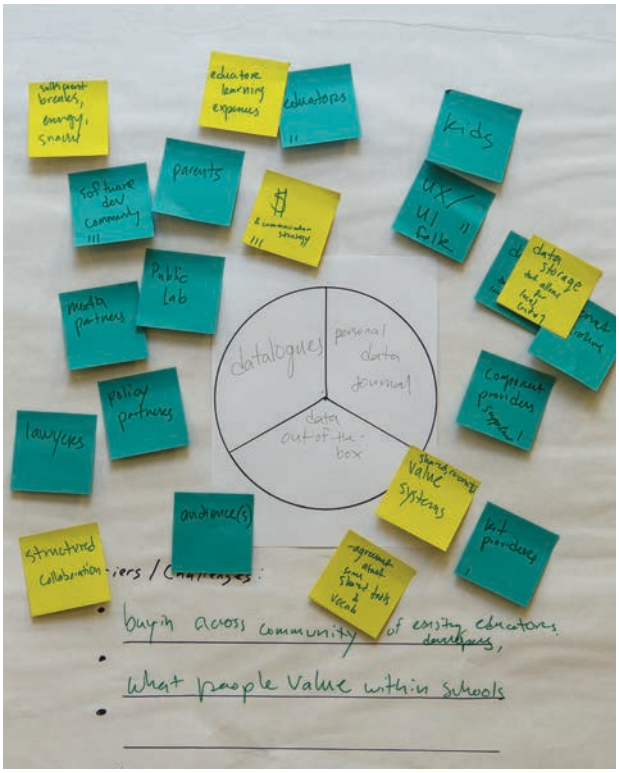
Section 5

Envisioning the Future

Imagining Possible Futures for Data-rich Experiences

Envision the future possibility of a data-fluent world. Now imagine the collective educational experiences needed to get there. This was the focus of *Designing 2030: Thinking & Doing with Data* to move from big ideas and questions to concrete ways to move forward as a community of educators, designers, and researchers toward possible futures with consequential, data-rich experiences.



"Learning informed and supported by data permeates across subjects, contexts, and communities. Data fluency is a means to an end, not an end in itself." — Helen Quinn

"When we think about data science in education, we need to look beyond tools and student experiences, to consider equity and the policy context. We cannot afford to repeat historical patterns of power and privilege with data, so we should look for opportunities to shift the balance of power through data ownership and control." — Daniel Edelson

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"Teacher Data Apprenticeships—modeled on Code for America brigades—provide a targeted professional development experience designed to support educators to work beside researchers in science and civic institutions to have a rich, authentic experience working with data themselves. Working as a cohort they develop strategies to bring data learning, case studies, lesson plans, and resources back to their classrooms and communities."
— Leigh Peake

"Visual journaling and correspondence about our daily lives, of the sort inspired by Georgia Lupi and Stephanie Posovec's Dear Data project, creates tactile, crafted artifacts and records data that's personal, meaningful, designed to be shared. Not only does this practice demonstrate that data are everywhere—not just in exotic scientific contexts—but it introduces everyone to the practice and utility of data representation, which reveals patterns that would otherwise go undetected." — Andee Rubin

Generating ideas

Participants were each given a sheet of paper sectioned off into three pie-shaped areas in which to articulate and document three promising ideas. With the "pies" pinned on a wall as a gallery of meeting artifacts, other participants posed clarifying questions or added to or extended the ideas.

Drawing from this collection as a fount of ideas, participants worked in small groups to select and develop one idea that was the most compelling to their group. As they added detail to their idea, participants articulated why their idea was important and what conditions would be necessary in order for it to come into being. Spurred by these concrete cases, they further surfaced tensions and articulated opportunities for data in education, identifying synergies, potential partnerships, and shared excitement across organizations and disciplines.

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Detailing Selected Ideas

A number of ideas and key themes emerged in this exercise.

Spaces to make data together

Imagine a place to make data! Is this local? Virtual? Perhaps both? Much like makerspaces, *data makeries* could be both physical meeting places and online community spaces in which to make data — to produce, explore, probe, display, storify, and more. They could introduce everybody—regardless of experience—to powerful tools, practices, and datasets.

Such spaces could also take the shape of portable or mobile pop-ups with "office hours" during which people could work with experts in different aspects of data science. Alternately, they could assume the form of events that offer many entry points, library resources for open-access and ongoing interaction, general-access workshops, public and collaborative art projects, and more.

Key ideas
More than simply a place, a "data makery" speaks to the idea that *culture and community need to be a part of data and education*. Mentors, shared passions, and connection, at both local and national scale, are vital to meaningful learning, and data allows for learning and collaboration across generations, rooted in social, civic, and environmental action.

"Seed bombs" for the data landscape

Modeled after activist events in which advocates of gardening and community beautification lob packets of seeds into abandoned or uncared-for spaces within a community, a "data seed bomb" is a collection of learning activities that could be easily taken up and around which learners would build shared data practices and skills. From "physical infographics" to balloon-mapping and computational crafts, these bite-sized data activities or "kits" would invite many points of entry to "doing things" with data. They could be implemented in a short time, while remaining easily extensible and scalable to more complex activities. These types of activities, such as data stories in social studies, could be akin to Giorgia Lupi and Stefanie Posavec's *Dear Data* project.

Key ideas
Learners need diverse ways to build experiences and see the many ways that data can be used to express, build, tell, and understand. There is a need for coherence and progression, but *learning is not always linear*. To appeal to a wide range of learners (and learning goals), experiences with data need to also be *creative, playful, and adaptable*, able to stretch across subjects and contexts.

Scaffolding civic data for all: Toolkits and networks

Two big ideas emerged around the need to go beyond access, in order to truly—and equitably—harness the power of civic data. Initiatives could empower engagement with civic and government data, allowing many people to play a role in seeking solutions to shared issues and concerns. Educators need a *set of tools, resources, datasets, and examples* that communities can use to understand and change how decisions are made, at the school, neighborhood, city, and national levels. This can include example code, scripts, or authentic datasets. These tools and resources would allow communities to tell their stories to themselves and to others, to reveal invisible patterns and effect change in power structures.

Secondly, creating this would also enable a network of people and tools to operate as pieces of civic infrastructure. By supporting connection across groups and issues, volunteers, civic hacking groups, and other peer networks could spur innovation and accountability in local government.

Key ideas
New kinds of data will shift how and what we know not just about STEM, but about many aspects of life and society. The power of data should not be concentrated in the hands of the relative few who already have power to make decisions. *Open data alone is not enough.* Placing sets of tools into the hands of users and showing them how to use them will help establish shared tool practices and ways to work with *data that are important not only to learners, but also to civic life and civil society*. Data has the potential to democratize knowledge-building and decision-making in the public sphere, but in order to reach this potential we need to be deliberate about putting infrastructure in place and ensuring that people across all sectors of society can use it (and build new parts).

Ongoing support and repeated experiences for learners and educators

Multiple ideas centered on how to support learning beyond one-off experiences or stand-alone resources. Ideas included developing a set of activities so that every year in every grade, at roughly the same time, students have a one- to three-week "data experience." Ranging from data faires to community science projects to building stories and models with data, annual data experiences could cross many different subject areas, carving out a space for engaging with data that lived, even if only briefly, outside some of schooling's tight curricular constraints.

Professional development and a professional learning community are also needed to bring educators together and give them preparation for teaching with data. With goals similar to the National Writing Project, this could be structured as an offering by 100 universities that host a residential program for teachers—a funded program so every teacher gets a chance to learn. Imagine a "data camp" for teachers.

Key ideas
To move from data literacy to data fluency means providing many and frequent *impactful experiences over time*.

Building a data fluency learning progression

In order to create data-fluent future, we need to understand and articulate what one looks like early on—defining what is foundational, what is advanced, and what is in between. We must help people build their data muscles, starting early and growing incrementally—and without injury. What might a "first bite" taste like, and how will learners move through a sequence or progression toward a "gourmet data meal"? Starting in early grades and progressing through secondary school and into higher education, we need to develop a model for data fluency education that centers around opportunities to teach and learn in ways that are agentive, critical, and responsive to learners' questions and aspirations—economic, social, or environmental.

Key ideas

Like the transition from learning-to-read to reading-to-learn, educators and designers must think beyond *learning about* data and data science, to *learning with* data and data science. This idea also speaks to the need for *a full conception of data fluency education*, including an outline of needed skills and tools, ways of thinking, and types of experiences learners will require.

Personal and persistent data production

Data journals, datalogues, and other ways of producing and controlling data about oneself could become powerful ways for learners to develop data-oriented "habits of mind" and learn how data connects to—and provides insight into—the world around us. Supports such as flexible modules, templates, and scaffolds for moving from well- to ill-structured data would build learner fluency while allowing for individual control over how and when data would be used. A journal could span formal and informal settings and be linked to a learning progression that incrementally builds skills and dispositions.

Key ideas

Data fluency requires not just learning the skills and tools to work with data, but seeing data as relevant to one's own life and community. We need to ensure that *we support learner ownership over data*—from questions and sense-making to practices and tools.

> It is easy to generate data. It is hard to make meaning from them.

Section 6

Connecting the Dots in the Landscape

Having identified and articulated their most promising activities for enacting data fluency, the group turned its focus to the horizon. In the future we imagine together, data fluency activities exist within a thriving learning ecosystem filled with organizations and opportunities focused on engaging with and better understanding data. Placing themselves in the future, participants turned their thoughts to what needed to exist for their vision of data engagement to come about.

Participants began by brainstorming the *actors*—individuals, groups, organizations, or similar entities—that would need to be involved to bring about their imagined future. These actors generate their own sets of demands and opportunities and have many interrelationships. Participants generated lists independently, then placed Post-it notes representing each actor on a central board. Repeating this process twice more, they generated and located necessary *conditions and connections* among these actors and identified *challenges* that would need to be overcome in order to make this future possible.

As they dynamically relocated elements of the landscape and expanded upon the initial groupings, a meaningful picture arose. By identifying potential affinities and synergies and adding a collective layer of comments, participants jointly painted a landscape of the imagined future and sketched a roadmap for collective action. As they brought the landscape mapping to a conclusion, participants situated themselves and their organizations within the communally imagined future. As a closing, each participant placed a marker of commitment on the landscape itself, identifying those places where they agreed they could and would take their first steps toward action.

With the future landscape mapped and participants' potential roles within it identified, the groundwork of a community was laid—participants were poised for further collaboration and engagement with future learning with data, and the themes that emerged from their collective recommendations supply a roadmap to a data-fluent future:

- Plant a firm foundation for data fluency education for all
- Activate a critical mass of people who can empower others to be data fluent
- Develop and embrace open-access tools and resources
- Support community voices, data ethics, and data for social good
- Foster interoperability and networking among programs, platforms, and organizations

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Plant a Firm Foundation for Data Fluency Education for All

In order to bring about a vision involving data fluency for all learners, we must start from a firm foundation that builds upon existing research into how people develop scientific and mathematical ideas around data. Becoming data fluent involves much more than simply understanding how to read a graph or chart. Data fluency involves understanding the life cycle of data and being conversant with its structure and transformation. It includes understanding the various ways data are produced across subject areas from biology and physics to computer science, social studies, language arts, and journalism. It includes being able to identify data in diverse sources and locations and bring them together fluidly with data tools in ways that generate new understanding. And it includes being able to communicate those understandings through both conventional and novel representations. Further, it includes appreciating the myriad issues that life in the Data Age brings to the table, including security, privacy, and equity, among others.

A step towards supporting *data fluency education for all* entails outlining a core set of concepts, competencies, and practices necessary to scaffold data fluency education. Concurrently, this education will also need to encompass areas such as digital citizenship, data privacy, and ethics education. These qualitative literacies as well as quantitative literacies can contribute towards building a developmental trajectory outline for data fluency applicable for a broad set of constituencies.

Previous efforts, both national and international, toward developing standards and definitions of data literacy represent valuable starting points for this work. Establishing this foundation in a meaningful fashion will entail building on the deep base of research around data from the science and mathematics literature. It will also involve simultaneously transcending the existing research base by mapping out new grand challenges for research into teaching and learning about data. This will need to acknowledge, for example, the fundamental differences between statistics and data science and the foundational transformations that computation has injected into all manner of conversations around data fluency. Convening and aggregating the current state of knowledge and expertise in these areas and mapping the field's gaps in knowledge will be an essential early step in this process.

Activate a Critical Mass

In order for data fluency efforts to succeed, we will need to ensure the existence of a critical mass of people across all fields. One thing that sets data fluency efforts apart from other efforts toward educational reform is the surprising diversity of stakeholders that need to be engaged for it to succeed. Clearly educators need to be central to this work, but even there, diversity is essential—engaging language arts teachers may be as important to success as engaging science or statistics teachers. Additionally, the research world has a crucial role to play in order to help define what is and isn't yet understood about data fluency and learning. Hand in hand with this research work, curriculum developers and providers must understand the need and rise to the challenge of providing the learning resources, datasets, and guidance necessary to enable educators and learners to build data fluency.

Where educators are concerned in particular, professional learning will be fundamental to the success of this work. Identifying and finding extended support for an educator community of practice around data fluency, potentially an interdisciplinary community, would provide an important avenue for building this capacity. The National Writing Project offers a successful model to be emulated—following a similar pathway to create a "Data Fluency Corps" could be one of the most important catalysts for the coming decade of data fluency education. Professional societies have a meaningful place in supporting awareness and facilitating learning around data fluency in a manner that is properly situated within educators' fortes and domains.

While most of the major new opportunities for this education reside at the pre-college level, universities have a primary role to play in the ecosystem. Engaging university faculty in emphasizing the need for data fluency and prompting university admissions departments to exert pressure for students' data fluency accreditation—and accepting it in novel, transdisciplinary forms—is essential to supplying the tacit permission for K-12 teachers to engage in these activities. Similar pressure and awareness can come from involvement on the part of companies and industry groups, who can also play a role in providing support for data fluency initiatives. On the more local side, community groups and local stakeholders may play significant roles in working with and understanding data in conjunction with schools or afterschool groups, often facilitated by organizations and individuals from the informal learning sector. These opportunities represent significant points of potential engagement, in many cases offering authentic, relevant, and long-term informal connections in the form of community projects and social connections across stakeholders.

Engagement will need to occur in stages, and different stakeholders' involvement will evolve as they become better versed in learning around data fluency and connect to more data fluency opportunities. Awareness is the initial stage—and the primary stage for most all the above groups at present. Identifying and funding efforts that raise awareness of the need for data fluency and the opportunities for furthering it is of prime importance at the moment. In a related vein, gauging public perception and identifying research-based methods for improving receptivity to the topic will be essential in ensuring a smooth start across stakeholder efforts. As awareness increases, identifying the clearest paths for various stakeholder groups to follow such that they can move their efforts forward while maintaining synergy across them all will be important. Supporting a dedicated backbone entity that can manage this awareness-building and facilitate this network coordination in the early years of the effort will be crucial to building momentum and maximizing impact.

Develop and Embrace Open-access Tools and Resources

The true power of data comes when learners are able to ask and answer their own questions of the data, making it their own by diving into data as a resource for inquiry. Building these habits of mind for learners, however, requires that they have the capability to work fluidly with data itself and that they do so across multiple experiences and venues over time.

Fluid exploration of data requires more than standard productivity tools. The tools of mere visualization or spreadsheet calculation pose constraints for learners when dealing with data. Instead, it is essential that learners work and learn with data tools, special tools designed for learning with and about data. Participants highlighted two specific tools oriented to this purpose: the Common Online Data Analysis Platform (CODAP) and Fieldscope. Additional projects such as iNaturalist and Vital Signs as well as many other data-focused projects are looking at ways to engage learners with data. In particular, open-source data tools provide opportunities for helping both learners and creators engage in new ways with data experiences, opening up chances for new innovation and extension of tools as new situations unfold. In the quickly changing area of data fluency, flexible tools are essential.

Having powerful tools is critical, but is only part of the equation for teaching and learning. Access to powerful *resources* is equally critical for helping educators bring data experiences to increasing numbers of learners. The first big recognition for the field is that there are many excellent existing resources to draw from. Decades of research into data and the fundamentals of learning statistics have given birth to many lessons and resources, from broad explorations to basic exercises that, if identified and opened up to the field, could help build a library for multiple grade levels.

The second recognition, however, is that the future we're heading toward is very loosely defined, such that many of the most vital resources in data fluency education have yet to be created. Formats and opportunities

in this new future abound. There will be a need for mini-courses for multiple aspects of data literacy, domain-specific units and modules ready for embedding into courses from mathematics to English literature, and full pathways for data science readiness. In order to encourage uptake across a broad range of educators, there will be a need for toolkits as well, general templates that allow educators and organizations to create the conditions for quality data inquiry.

A series of toolkits can help ensure that stakeholders have opportunities to get started with data fluency activities no matter their grade level or prior experience with data fluency education. Opportunities include supporting "Dear Data"-style postcard kits and activities, starter templates and resources for developing "data science faires" within a school or district, or kits for beginning an afterschool data club, among others. Hackathons, camps, or other in- and out-of-school opportunities will provide multiple points of entry. In particular, a nationally promoted "Day of Data" opportunity with a central resource kit and website would be an ideal format for furthering these activities. Highlighting these toolkits and resources and ensuring that they find ready audiences will be important.

Across all, a thoughtful approach and philosophy may prove as essential as the materials themselves. Supporting the time, energy, and thought necessary to generate resources for the new world of data fluency will be critical for building the field's capacity. Ensuring that they are designed to leverage the use of data tools where appropriate will build learners' abilities. Releasing materials as open resources whenever feasible will ensure broad uptake, provide a way into equitable access, and tap into common creativity across the field.

Support Community Voices and Data for Social Good

Data provide a key lever for relevance and youth engagement at many levels. They also provide inroads to significant problems in the real world. Data fluency activities and opportunities must acknowledge the importance of these questions if they are to be embraced by today's youth. Equally importantly, data-relevant engagement may supply meaningful opportunities for communities to come together around issues that have common resonance.

By engaging stakeholders across communities, schools and organizations can bring together perspectives and individuals that might otherwise stay separate. Youth can engage with fishermen to address issues facing the future fleet. Water officials can work with schools to monitor and understand community water quality questions. School officials can work with youth to gather data on the happiness of students within a school. And such opportunities are not only chances for youth to practice data fluency in real-world contexts. In many rural communities in particular, schools represent significant sources of "science capital," making students' perspectives and data-collection capabilities valuable assets for teasing out solutions to community problems.

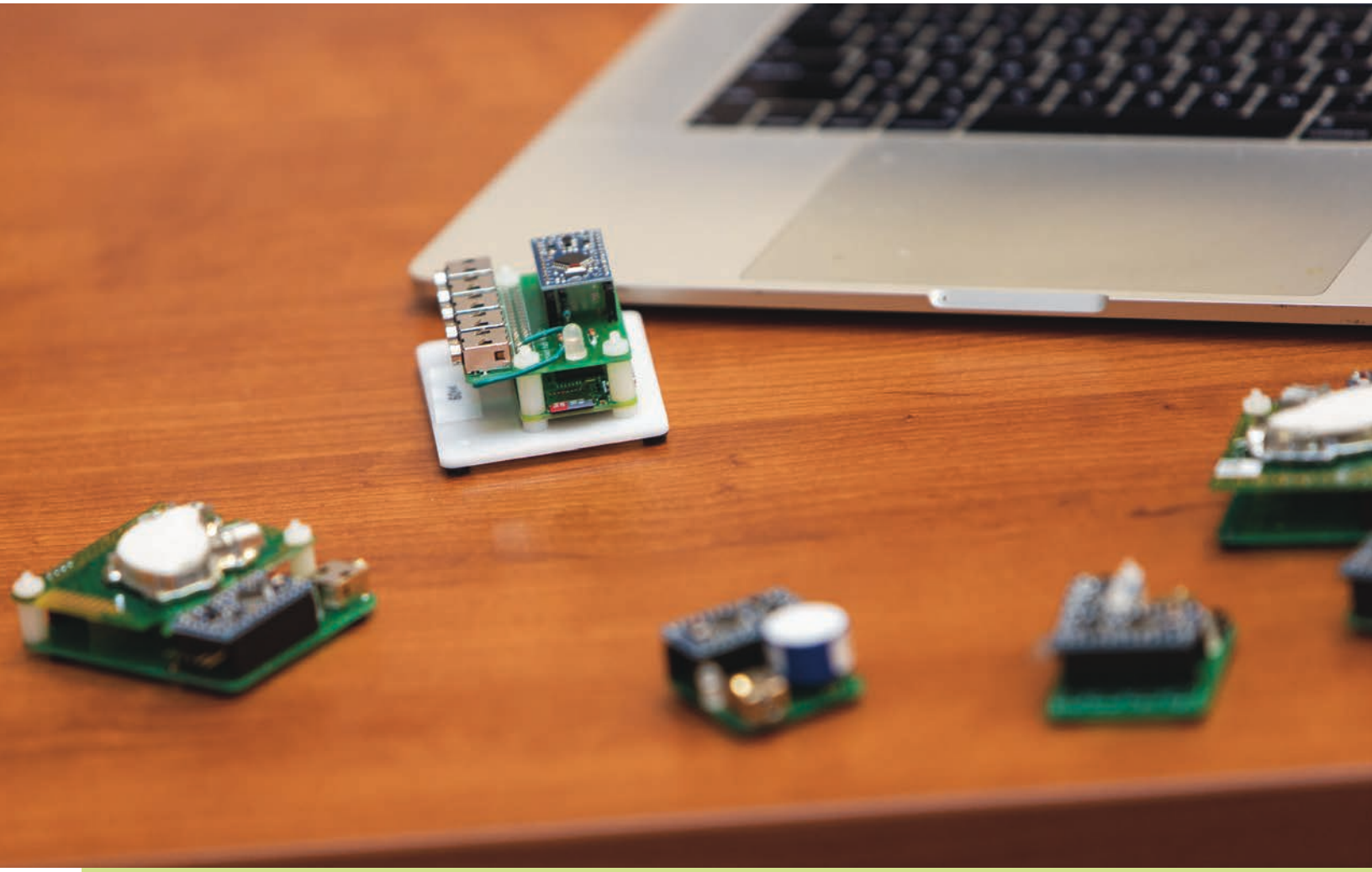
Such community involvement represents a model that a variety of projects have played out in multiple ways. Aggregating the learnings across these projects and understanding how they can apply across a wide range of geographies, cultures, and population sizes as well as what variations make them robust across settings from urban to rural represents an important opportunity. If a set of templates were drawn from existing work and fleshed out for robustness, entities from schools to museums to libraries and more could serve as hubs for a series of data-intensive community inquiry projects across the nation.

Social and community interactions also offer many opportunities for considering other aspects of data in the modern world. Ever-present questions around data citizenship become especially salient when youth work with locally relevant problems. Overall, ensuring that issues of privacy, security, empathy, ethics, bias in data selection and algorithms, and other concerns surrounding the full envelope of data and the data life cycle are essential aspects of preparing data-fluent future citizens and workers.

Foster Interoperability and Networking

Bringing data fluency to schools and informal learning at large demands connection and knowledge sharing above all. Truly bringing about data fluency will require coordinated action among policymakers, states, professional organizations, practitioners, research organizations, data providers, curriculum developers, technology developers, and professional developers, among others. Network building will also be essential to providing the necessary conditions for success. This includes bridging across and among organizations and individuals, assembling and establishing open exchange around knowledge and resources, identifying and helping fill gaps in emerging networks within the field, and ensuring interoperability of knowledge and technical resources. Working in concert to lift up the efforts of others, a coalition will enhance the diverse work needed for success of the field as a whole.

In some areas, coordination and interoperability at a high level will be necessary to enable and buoy efforts at the individual learner level. For example, one of the biggest barriers to establishing widespread data fluency is the difficulty of obtaining data in a form that is useful for engaging learners. Currently there are few accessible, "just-right" datasets that are appropriately complex for rich discovery yet clean and findable enough for everyday use. Developers and providers of data, including federal agencies, have a strong interest in making data accessible, yet little experience thinking about the problem through the lens of learning. Exemplars, precedent, guidance, and support will be needed to incentivize and assist such groups to make datasets not just accessible, but interoperable and with low barriers to analysis.



> No significant problem can be tackled without people who are data fluent.

Final Thoughts

Furthering data fluency at a wide scale is essential to the future prosperity and success of our environment and society as a whole. Ensuring that data fluency is fostered, nurtured, and promoted in such a way that it can take flight as a field, across both formal and informal learning alike, is one of the most critical challenges of the current era. Establishing connections, fostering understanding, and inspiring action will be essential to building a future filled with informed and fluent individuals, workplaces, and communities prepared for life in the Data Age.

Building data fluency by 2030 will not emerge spontaneously. Developing change at scale demands intentional guidance. Providing support and coordination through the collective actions of a coalition may act as a catalyst to bringing about data fluency at the rate the changes in society make necessary. Such a coalition could act both behind the scenes and in front of them as necessary, helping build networks, foster exchanges, grow synergies, assemble research, and coordinate knowledge. Directed by multiple stakeholders, such a coalition will be critical in ensuring success by continually identifying and furthering the interests of the many stakeholders. It will also carry the torch within the field overall, keeping the role of data fluency broad and ensuring that it does not become prematurely siloed into a single discipline or educational category.

Section 7

Supplementary Resources & Documentation

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Meeting Agenda

Day 1: January 29, 2019

2:00 pm Demonstrations

Dataflow - Lisa Hardy
Data Science Games - William Finzer
Open Data, Open Minds - Elisabeth Sylvan & David Cole

2:45 pm Demonstrations

iNaturalist - Scott Loarie
Vital Signs - Leigh Peake
FieldScope - Daniel Edelson

3:30 pm Welcome & Framing

Keynote: Chad Dorsey

4:00 pm Group Activity: Build Social Glue

Part 1: Describe people in your clan, tribe, or affinity space

Part 2: Data learning experiences: The perfect recipe

5:15 pm Solo Activity: Desired Outcomes Survey

5:30 pm Adjourn

Day 2: January 30, 2019

9:00 am Welcome & Review

9:30 am World Café

Three Topics - 30 minutes each

11:00 am Solo Activity: Three Slices of Pie

Generate your three big ideas on chart paper
Rotate and write down questions
Gallery walk and pick your slice

12:00 pm Lunch

Keynote: Shannon Dosemagen, Public Lab

Keynote: Lissa Soep, YR Media

1:00 pm Slice Detail Design

Find your slice
Detail the experience

2:00 pm Presentation & Discussion

3:00 pm Group Activity: Landscape Mapping

4:30 pm Next Steps

5:00 pm Adjourn

References

Erickson, T., Wilkerson, M., Finzer, W., & Reichsman, F. (2019). Data moves. *Technology Innovation in Statistics Education*, *12*(1). Retrieved July 1, 2019, from https://escholarship.org/uc/item/0mg8m7g6#main

Hoffman, A. L. (2018). Data Violence and How Bad Engineering Choices Can Damage Society. Medium. Retrieved July 1, 2019, from https://medium.com/s/story/data-violence-and-how-bad-engineering-choices-can-damage-society-39e44150e1d4

Mandinach, E., & Grummer, E. (2016). *Data literacy for teachers*. New York, NY: Teachers College Press.

Related Resources

The following resources were mentioned during the conversations as well as shared by participants as relevant to the discussions around data science education.

Readings

Ballard, H., Harris, E., & Dixon, C. (2018). Science Identity and Agency in Community and Citizen Science: Evidence & Potential. Report to the National Academies' Committee on Designing Citizen Science to Support Science Learning. http://hub.mspnet.org/index.cfm/33673

Finzer, W., Busey, A., & Kochevar, R. (2018). Data-driven inquiry in the PBL classroom. *The Science Teacher, 86*(1), 28-34.

Govenor, D., Bowen, M., & Brunsell, E. (2016). *Big Data Small Devices: Investigating the Natural World Using Real-time Data*. NSTA Press.

Kastens, K. (2014). Pervasive and Persistent Understandings about Data. Retrieved August 24, 2018, from http://oceansofdata.org/our-work/pervasive-and-persistent-understandings-about-data

Konold, C. Higgins, T., Russell, S. J., & Khalil, K. (2015). Data seen through different lenses. *Educational Studies in Mathematics, 88*(3), 305–325. https://doi.org/10.1007/s10649-013-9529-8

Lee, C. H., & Soep, E. (2016). None but ourselves can free our minds: Critical computational literacy as a pedagogy of resistance. *Equity & Excellence in Education, 49*(4), 480–492. https://doi.org/10.1080/10665684.2016.1227157

Lee, V., & Wilkerson, M. (2018). Data use by middle and secondary students in the digital age: A status report and future prospects. *Instructional Technology and Learning Sciences Faculty Publications*. Retrieved May 5, 2019, from https://digitalcommons.usu.edu/itls_facpub/634

Lupi, G., & Posavec, S. (2018). *Observe, collect, draw!: A visual journal*. New York, NY: Princeton Architectural Press.

Ocean Tracks – A Journey Through the Ocean: A Modern Approach to Science Education (2019). *Scientia*. Retrieved July 10, 2019, from https://www.scientia.global/ocean-tracks-a-journey-through-the-ocean-a-modern-approach-to-science-education/

Quinn, H., & Bell, P. (2013). How designing, making, and playing relate to the learning goals of K-12 science education. In *Design, make, play: Growing the next generation of STEM innovators* (pp. 17–33). London: Routledge.

Online Resources & Tools

Algorithmic Justice League
www.ajlunited.org

City Dashboards: Crafting Local Data Stories
www.nexmap.org/open-data-open-minds

Common Online Data Analysis Platform
codap.concord.org

Data.gov: U.S. Government open data
www.data.gov

Data Science Games
concord.org/data-science-games

Dear Data
www.dear-data.com

ESRI Online Mapping Instructional Resources
www.esri.com/en-us/industries/education/schools/instructional-resources

FieldScope
www.fieldscope.org

Google Earth Education
www.google.com/earth/education

iNaturalist
www.inaturalist.org

International Data Science in Schools Project
www.idssp.org/pages/purpose.html

Jose Duarte Infographics
cargocollective.com/visualounge/Jose-Duarte-Infographics

NASA's Data Portal
data.nasa.gov

NOAA Data Discovery Portal
data.noaa.gov

Oceans of Data Institute
oceansofdata.org

Seeing Theory
seeing-theory.brown.edu

STEM Literacy for Infogrpahics (SLI project)
science-infographics.org

Tableau
www.tableau.com

Tuva Labs
tuvalabs.com

USA Facts
usafacts.org

YR Media's DIY Toolkit for Storytelling
yr.media/diy/diy-toolkit-telling-stories-with-data

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DESIGNING 2030

The Concord Consortium