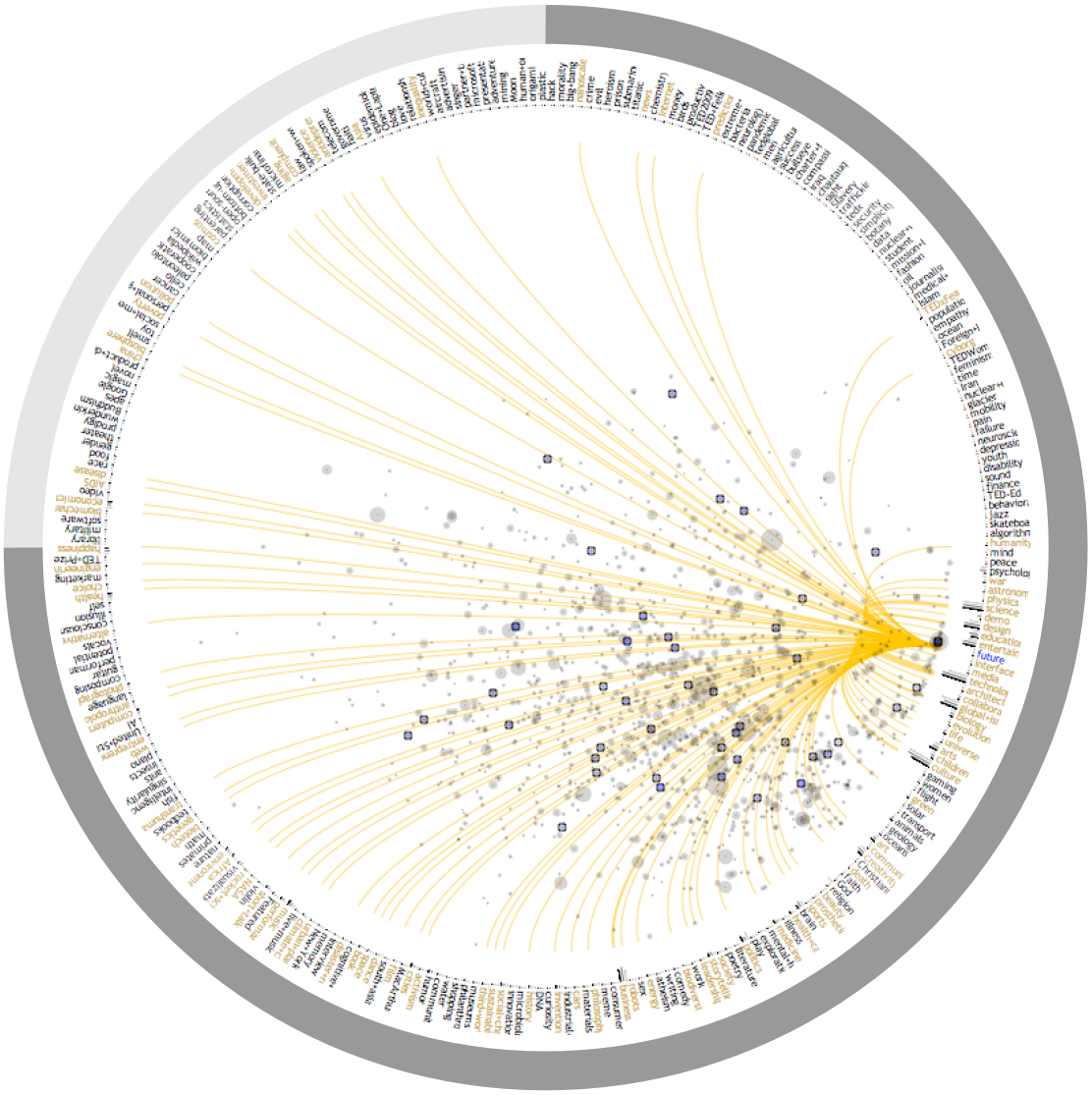
INTER-
ACTIVE



DATA

1 lecture

3 lectures

1 credit hour

3 credit hours

Overview

From finding the source of cholera outbreaks (Rogers 2013) to optimizing train schedules (Rendgen 2019), the powerful human visual system (Ware 2021) enables our brains to interpret huge sums of information, building graphical languages that help us grapple with information symbolically and solve problems in a way that fundamentally changes our relationship to mathematics (Victor 2013), science (Clegg 2021), and storytelling (Harris 2007). However, the interactive nature of digital media has fundamentally changed the possibilites of this reasoning process through new kinds of "dialectic" experiences (Pottinger et al 2024). Creating new conversations in which tools talk back, these new digital media enable us to “think thoughts we couldn’t think before” (Victor 2013), entering a fruitful meeting ground between art, design, and computation. Here we can see gun deaths in mass (Periscopic 2018), listen to the internet’s emotions (Harris and Kamvar 2015), and collaboratively reason about policy solutions to our species’ most pressing environmental issues (Pottinger et al 2024).

This open source Creative Commons guide offers four versions of interactive data coursework, providing model cirricula that all extend a welcoming invitation into this cross-disciplinary tool-chest. In the process, it traverses cognitive science, information design, game design, and computer science to explore how those interested in building the future of our physical and digital worlds can create new media for exploring and communicating data (Victor 2011). Those interested may include:

Scientists

exploring how novel data visualizations can change the way they and their audiences understand data.

Artists

experimenting with how interactive media can create exciting data-rich emotional experiences.

Mathematicians

creating new tools for reasoning about complex systems through computation.

Designers

playing with visual cognition and data interpretation in the built environment.

No matter from where you are joining from, we hope you can find a home here in the creative space between disciplines to tell new stories and build new knowledge

Options

This guide offers four options of varing lengths to support different opportunities. The goal is that interactive data content can fit into existing coursework or entirelly new offerings at varying degrees of commitment.

One Lecture

Providing inspiration within around an hour, slotting into an existing course without major modification.

Three Lectures

Focusing on off-the-shelf charts, augment an existing Python course and get the very basics needed for a data professional.

One Credit Hour

Dig into the theory and build novel interactive data graphics by combining information design, cognitive science, game design, and computation. Put your skills into practice with an end to end project and practical high-level discussion of ethical and social concerns.

Three Credit Hours

Explore information design and learn now to craft novel interactive experiences. Leverage cognitive science, game design, and information design to leverage existing off-the-shelf solutions in addition to building novel representations. Furthermore, learn how to create emotional experiences through data and how to ethically / inclusively build new digital media, understanding information as both mathematical and social artifact. Finally, master your new creative skills with hands-on projects.

One Lecture

This guide starts with what can be done in about an hour. This first format posits that the best way to understand these capabilities is to experience them across different disciplines. The goal for a short session is to inspire future projects, showing what is possible but exploring how. In three parts instructors are encouraged to allow students to play with the final example of each section for group conversation.

Movement 1: Comprehending

We normally think of visualizations as tools of communication but, before that, they also help us make sense of our work. These 4 examples show how we can use visualization in sense-making.

Cholera Map

A classic example of early data visualization that allowed John Snow to uncover the source of choleara (Rogers 2013).

NASA Vortex

Building tools for scientists to see their own data in new ways: “They’d never seen their data like this before... There’s a cadence of frequency to my event records, oh my god!” (Binx 2016)

We Feel Fine

How we can reveal hidden stories in We Feel Fine, allowing for a human experience of emotion at scale (Harris and Kamvar 2015).

Ag Adapt

A look at regenerative agriculture and how the tools evolve with thinking even before the answer is found (Pottinger et al 2024).

Movement 2: Communicating

Having found results to share, we turn to sharing findings with others.

Mortality

Nightengale charts as a way to tell the story of suffering to motivate public change (Andrews 2022).

Gun Deaths

An arresting example of using data to invoke emotional response regarding US gun violence (Periscopic 2018).

Being Wrong

Uniquely using interactivity to engage misconception, the New York Times explores the value of being wrong in a safe space (Katz 2017).

Alaska

Taking a trip to the Gulf of Alaska using Pyafscgap, a guided tour to builds sophisticated scientific stories (Pottinger and Zerpelleon 2023).

Movement 3: Constructing

Visualizations don't only reveal findings, they help construct solutions. This final movement asks how interactive data can help users build their own solutions.

Trains

Marey Diagrams and an early example of a thinking tool that aids engineers and designers (Rendgen 2019).

Cars

Driving our Future simulation shows what tools for solution design might look like, revealing a new kind of interactive data (Keith 2017).

Climate

Zooming out even further on the climate crisis, an interactive tool (En-ROADS) for data workshops tries to find common policy ground (Chaudhry 2023).

Plastics

Finally, we look at a tool which traveled to the UN to explore specific policy package design, creating collaborative media for thought (Pottinger et al 2024).

Three Lectures

Fitting into an existing course, how can one week (three lectures in a 3 credit hour course) offer the basic tools to visualize data interactively? Leaving most of the theory to optional supplemental reading, this crash course focuses on efficiency for the core skills of interest to a general audience. Python is prerequisite.

Day	Reading	Material	Exercise [& Homework]

● Movement 1: Charts

Start by focusing narrowly on existing charts and selection from among options, offering practical immediate tools.

○ Three Variables

What are the options for plotting and when might you want to consider one versus another? We explore the basics through the lens of the US Census Microdata.

01	Introduction to Plotting with Matplotlib in Python (Babitz 2023)	- Options and effectiveness of encodings (Cleveland and McGill 1984) - Dimensionality: types and number of variables (McDonald 2014)	- Plot salaries - Plot salaries by age - Plot salaries by age, gender - [Homework Due 02] Plotting salaries by age, degree

○ Four Variables

We ended our first look at the data by plotting three variables together but what about four or more?

02	Data Visualization: Choosing a Chart Type (Berkeley 2024)	- Shared axes (Hunter et al 2024) - Small mulitples (Gemignani 2021; Tufte 2013) - Embedded summaries (Tufte 2013) - US econ case study (Pottinger 2012)	- Plot salaries by gender, age - Add degree subplots - Add annotation - [Due 03] Plot count by gender, age, sector

● Movement 2: Interactions

How do we best take advantage of digital media's interactivity?

○ Beyond the Chart

We've used digital tools to create static plots but the unique nature of these tools is their ability to respond to the user. What becomes possible in "dialectic" experiences?

03	Thinking Through Visualization Tools (Pottinger 2023)	- Explorable media (Victor 2011) - Accessibility (Fossheim 2022) - Income Gaps (Pottinger 2022) - Purposes of data viz	- Lookup mean salary by degree (nbwidgets) - Compare salary by gender, age - Compare degress w/ selectable metric - [Due 04] Add select between gender and race

One Credit Hour

This one credit hour course explores the human visual system as well as information / game design principles, providing the skills needed to make digital tools that help understand data, tell stories with results, and foster data-informed collaboration. Using information design as a way into interactive media, this offering provides participants competency in crafting custom interactive data experiences but leaves some of the details to a longer 3 credit hour opportunity. Prior programming experience required: Python recommended but not required.

Movement 1: Primitives

What are the goals of information graphics and what are the tools to achieve them? The course starts with an overview of what is possible before turning to the the basic elements available for data graphics and how the human visual system processes those options differently.

Movement 2: Combinations

With the building blocks in hand, instruction turns to different chart types before understanding the limitations of prebuilt graphics. Finally, the course explores the principles required to make new visual languages beyond what is available off the shelf.

Movement 3: Responses

Thinking critically about the user as more than a mere decoder of visual data, the course asks how the user can become an active participant in creating experiences, adding interactivity to data visualization.

Movement 4: Mastery

The course ends with a practical opportunity to complete a new visualization from start to finish.

Primitives

30 points

● ● ●

● Here we start with what ingredients are available for data visualizations and interactive data experiences, using foundational resources to frame how to think about them.

Day	Reading	Material	Exercise [& Homework]
○ Why Interactive Data			
	Focusing first on inspiration, the best way to understand these capabilities is to experience them.		
01	None	- Comprehending: Cholera (Rogers 2013), NASA Vortex (Binx 2016), We Feel Fine (Harris and Kamvar 2015) - Communicating: Nightengale Charts (Andrews 2022), Gun Deaths (Periscopic 2018), Draw It Yourself (Katz 2017) - Constructing: Marey Diagrams (Rendgen 2019), Driving our Future (Keith 2017), En-ROADS (Chaudhry 2023)	- Ag Adapt (Pottinger et al 2024) - AFSC GAP (Pottinger and Zarpelleon 2023) - Global Plastics AI Policy Tool (Pottinger et al 2024)
○ Hello Python			
	● An orientation session to help participants coming from languages beyond Python to get ready. This will be a fast paced intro geared towards existing programmers but it also offers optional additional resources.		
02	Optional: A Byte of Python (Swaroop 2023)	- What is Python and why use it. - Variables, functions, objects - Online sketchbook	- Taking an action (command / loop) - Building a language (functions and objects) - Draw rectangles (libraries) - [Homework due Day 03] Draw circles
○ Drawing Digitally			
	● Digging into the creation of digital media and creative coding, we have our first in-person code jam that offers the experience of collaboration and sharing of creative output. This adds computation and interaction to visual primitives.		
03	Media for Thinking the Unthinkable (Victor 2013)	- PLATO - Processing - Sketchingpy	- Draw a line - Draw a cirlce - React to the user - [Due 04] Reseponsive doodle
○ Drawing with Glyphs			
	● We look at fundamental shapes through cognitive science experiments. This offers us the fundamental visual building blocks of data graphics. Go through a sample economics problem with up to 4 variables.		
04	The Web's secret stories (Harris 2007)	- Gestalt (Portnow 2018) - Preattend (Ware 2021) - Color (Ware 2021) - Cleveland and McGill (1984) - Taxonomy of common charts	- Chart for 1 variable - Chart for 2 variables - Chart for 3 variables - [Due 05] Chart for 4 vars

Combinations

40 points

Now that we have the basic building blocks, we see how those combine into the common "patterns" we see in our daily lives and how we can use existing code to generate those charts. However, we then keep following these principles until hitting visualization escape velocity when we make our own new visual representations.

Day	Reading	Material	Exercise [& Homework]

Drawing with Data

Adding design into art, we look at interacting with the file system from a creative coding context and how to direct the computer to draw from non-human inputs, adding our final primitive ingredient for now: data.

05	Nicholas Felton (2011)	- Data formats and records - Building numeric scales - Building other scales - Transformations on data (map, filter, reduce, etc)	- Loading US microdata sample - Drawing age and salary - Switching to text - [Due 06] Draw salary and degree

Drawing with Pre-Built Charts

We start with the fast route to graphics: someone else's charts. Using matplotlib, this conversation gives us the most direct option in our tool chest but, centered in patterns, also one of the most limited.

06	Thinking Through Visualization Tools (2023)	- A tour of charting libraries - A tour of matplotlib	- Loading US microdata sample - Drawing age and salary - Changing axes - [Due 07] Draw salary and degree

The Limitations of Patterns

Continuing our exploration in charts you maybe haven't heard of, we start to ask why patterns are helpful but also what happens when patterns stretch so far that they start to break back down into primitives. We also take a look at Tufte who started one of the most important information design schools of thought.

07	Review of Tufte's "The Visual Display of Quantitative Information" (LeRoy 2018)	- Less common patterns: sparklines, small multiples, sloegraphs, Sankey, arc, chord - Dissecting Happiest Jobs in Tech (Pottinger 2019)	- Draw age, salary, gender - Draw embedded summaries - Add degree - [Due 08] Redo the graphic with a new encoding.

Visual Languages

Conversation shifts to data visualization techniques that depend on and leverage context, using the concept of a symbolic language to reveal what is possible outside of prebuilt graphics.

08	Lupi and Posavec (2015)	- The concept of movements (Harris and Kamvar 2015) - A dissection of Podcast Anthropology (Pottinger 2015)	- Draw your day - Draw your last 5 years - Draw it again a different way - [Due 09] Draw your next 5 years

Responses

30 points

Now examining data graphics as a language whose rules afford creativity and innovation, we encounter the final primitive: the player. Indeed, we ask what happens if we imagine the reader as more than a decoder of information but an active participant in sense making.

Day	Reading	Material	Exercise [& Homework]

The Role of the Reader

We look at the 3 waves of human-computer interaction, covering key concepts such as affordances, social actors, gameplay loops, working memory, and coordination.

09	- The Role of the Player (Portnow 2011) - Explorable Explanations (Victor 2011)	- History of HCI (Duarte and Baranauskas 2016) - Concepts: affordances (Norman 2013), working memory (Ware 2021), social actors (Nass et al 1994) - Game design loops (Brazie 2024)	- Loading and drawing BART data - Interacting with the plot - Coordinated scrubbing (weekend + weekday) - [Due 10] Add additional month

The Reader as a Partner

Spending some more time with design disciplines that co-create with the user, we turn to how interactivity engages with user expectations and how the user engages with themselves.

10	Super Mario 3D World's 4 Step Level Design (Brown 2015)	- Juxtaposition Gratification (JM8 2024) - Ludonarrative (Hocking 2007) - Defying user expectations (Katz 2017) - Food Sim SF (Pottinger 2023)	[Due 12] Write on experience of one of the following: The Cosmic Wheel (Deconstructteam 2023), FTL (Ma and Davis 2012), Spiritfarer (Thunder Lotus 2020), Papers Please (Pope 2013), Unpacking (Brier and Dawson 2021)

Architecture

With the elements of an interactive experience in place, we turn to various forms of level design, exploring how structure creates experiences and encourages different roles for the user.

11	How Nintendo Solved Zelda's Open World Problem (Brown 2023)	- Linear gameplay and Hayashida design (Pottinger and Zarpelleon 2023) - Semi-linear: Ag (Pottinger et al 2024) - Non-linear: Plastics (Pottinger et al 2024)	Share experiences of games so far

Mastery

40 points

- Wrapping it up with some final thoughts before turning over the stage to celebrate the class' own visualizations.

Day	Reading	Material	Exercise [& Homework]

Measurement and Evaluation

Now that we are building experiences, what can statistics, anthropology, and game design tell us about evaluating the effectiveness of our work? We look to the values of measurement before turning to what happens when the wall between designer and users begins to break down.

12	Designing for Realtime Spacecraft Operations (Binx 2016)	- Quantitative (Munzner 2014) - Thinking-Aloud (Lewis 1982) - Diary studies (Chneiderman and Plaisant 2006) - Participatory Design (IxDF 2023) - Generalizable knoweldge vs quality assurance	- Share final experiences of games - [Due final] Introduce final project (30 points)

Access and Ethics

Not everyone experiences the world the same way and not everyone has the same privilege or representation when they do. In our final lecture, we look back at what we've learned to understand how our work interacts with the broader built environment and the power structures woven into it.

13	Games are for Everybody (Brown 2018)	- Intro WCAG - Common accessibilty patterns - Representation (Pottinger 2019) - When visual isn't available	[Due final] How do you think about ethics in your final? (10 points)

Coding Help

14	None	None	None

Final

We use our final time together during finals week to share our work with each other, celebrate our new tool chest, and experience the diverse interpretations of this curriculum.

15	None	None	Peer sharing in which participants split into two group and have two sessions of presentation (group a shares to group b then visa versa) in a booth setting.

Three Credit Hours

Create sophisticated tools for understanding and collaborating through data. This three credit hour course situates data visualization within traditional information design before branching out into interaction and game design. Rooting conversation in both theory and practice, discussion spans cognitive science and practical programming to art and visual design. Participants will gain valuable concrete skills to iteratively interrogate their own data, build compelling experiences to share their results, and craft engaging interactive environments. In this process, participants will understand data not just as a mathematical artifact to be conveyed but as socially mediated information with emotional experience and ethical responsibility. Prior programming experience required: Python recommended but not required.

Movement 1: Hello

Motivation for why one may employ interactive data experiences before ensuring a common basic Python skills across the course participants.

Movement 2: Primitives

A tour through the foundational artistic thinking and science that underpins modern data visualization, detailing the building blocks available to data graphics.

Movement 3: Sketches

Some exercises in sketching with code to gain familiarity with important technologies and their role.

Movement 4: Combinations

An exploration of existing patterns (charts) including their usefulness and limitations before exploring the tools available to make new graphical representations / languages.

Movement 5: Practice

Pausing for a moment of hands-on practice on an end-to-end visualization project.

Movement 6: Responses

Touring philosophy and various design disciplines, we reconceptualize the role of the reader as an active participant to arrive at the various ways in which interactivity enable new experience.

Movement 7: Context

Contextualizing prior lessons socially and scientifically, looking to measurement / evaluation, accessibility, ethics, and software engineering.

Movement 8: Simulations

Stopping by Montessori, we consider the role of digital media in empirical play both for communication and in creating new knowledge.

Movement 9: Mastery

Ending with a hands-on opportunity to apply the course's ideas, instruction ends with supporting final projects shared in a class-wide festival.

Hello

20 points

- Before we get started, we take in some inspiration, basic history, and essential skills, setting the stage for our cross-disciplinary journey.

Day	Reading	Material	Exercise [& Homework]

Hello Visualization

Focusing first on inspiration, the best way to understand these capabilities is to experience them across different disciplines.

01	None	- Comprehending: Cholera (Rogers 2013), NASA Vortex (Binx 2016), We Feel Fine (Harris and Kamvar 2015) - Communicating: Nightengale Charts (Andrews 2022), Gun Deaths (Periscopic 2018), Interactive World Migration Report (IOM 2024) - Constructing: Marey Diagrams (Rendgen 2019), Driving our Future (Keith 2017), En-ROADS (Chaudhry 2023)	- Ag Adapt (Pottinger et al 2024) - No Ceilings (Fathom 2016) - Global Plastics AI Policy Tool (Pottinger et al 2024)

Hello Python

- An orientation session to help participants coming from languages beyond Python to get ready. This will be a fast paced intro geared towards existing programmers but it also offers optional additional resources.

02	Optional: A Byte of Python (Swaroop 2023)	- What is Python and why use it. - Variables and functions - Online sketchbook	- Taking an action (command / loop) - Building a language (functions) - Draw rectangles (libraries) - [Homework due Day 03] Draw circles

Hello Objects

- Continuing an introduction to Python as required for the course.

03	Media for Thinking the Unthinkable (Victor 2013)	- Objects - Encapsulation - Polymorphism	- Defining a shape - Building multiple shapes - Drawing polymorphically - [Due 04] Add color

Primitives

30 points

- Here we start with what ingredients are available for data visualizations and interactive data experiences, introducing foundational resources to frame how to think about these building blocks.

Day	Reading	Material	Exercise [& Homework]

Visualization as Design

- A critical look at Tufte who started one of the most important information design schools of thought and how information design has evolved since.

04	Review of Tufte's "The Visual Display of Quantitative Information" (LeRoy 2018)	- Examples of problematic graphs (Tufte 2013) - Chart junk (Tufte 2013) - Tuftean axes (Tufte 2013) - After Tufte (Elliot 2016)	- A look at a matplotlib chart - Removing chart junk - Adding a tuftean axis - [Due 05] Critique a recent data graphic from the news.

Visualization as Science

- We continue with an understanding of how the human visual system processes information and some early hints as to what the primitives of data visualization might be.

05	Preattentive Attributes in Visualization (Kesavan 2016)	- Stages of visual processing (Ware 2021) - Visual working memory (Ware 2021) - Preattentive features (Ware 2021) - Gestalt / neg space (Portnow 2018)	- Load tabular data on model accuracy - Add bolding - Add heatmap - [Due 06] Build heatmap of job satisfaction factors.

Formalizing Glyphs

- We next turn to a foundational study offering us the fundamental visual building blocks of data graphics.

06	How William Cleveland Turned Data Visualization Into a Science (Pricenomics 2016)	- Clevland and McGill (1984) - Taxonomy of charts	- Chart for 1 variable - Chart for 2 variables - Chart for 3 variables - [Due 07] Chart for 4 vars

Sketches

40 points

- Before exploring visual languages, we experiment with different visual forms and, practically, how to draw with data in digital media using different libraries.

Day	Reading	Material	Exercise [& Homework]

Drawing Digitally

- Digging into the creation of digital media and creative coding, we have our first in-person code jam that offers the experience of collaboration and sharing of creative output. This adds computation and interaction to visual primitives.

07	Inventing on Principle (Victor 2012)	- Processing - Sketchingpy	- Draw a line in a loop - Draw a circle in a loop - Drawing with the user in a loop - [Due 08] Responsive art 1

Deconstructing Drawing

- Continuing to explore digital drawings as a way to understand and experiment with glyphs.

08	OpenProcessing	- Stroke, fill, color (Ware 2021) - Primitive shapes - Options for input - Fonts and text	- Coding help - [Due 09] Responsive art 2

Drawing with Data

- Adding design into art, we look at interacting with the file system from a creative coding context and how to direct the computer to draw from non-human inputs, adding our final primitive ingredient for now: data.

09	Nicholas Felton (Felton 2011)	- Data formats and records - Building numeric scales - Building other scales - Transformations on data (map, filter, reduce, etc)	- Loading US microdata sample - Drawing age and salary - Switching to text - [Due 10] Draw salary and degree

Prebuilt Charts

- We continue with the fast route to graphics: someone else's charts. Using matplotlib, this conversation gives us the most direct option in our tool chest but, centered in patterns, also one of the most limited.

10	Thinking Through Visualization Tools (2023)	- A tour of charting libraries - A tour of matplotlib	- Loading US microdata sample - Drawing age and salary - Changing axes - [Due 11] Draw salary and degree

Combinations

40 points

- Before exploring visual languages, we experiment with different visual forms and, practically, how to draw with data in digital media using different libraries.

Day	Reading	Material	Exercise [& Homework]

Patterns

- Continuing our exploration in charts you maybe haven't heard of, we start to ask why patterns are helpful but also what happens when patterns stretch so far that they start to break back down into primitives.

11	The Web's secret stories (Harris 2007)	- Sparklines, small multiples, slopegraphs (Tufte 2013) - Developer Happiness (Pottinger 2019) - Shared axes (Tufte 2013)	- Draw age, salary, gender - Add summaries - Add degrees - [Due 12] Redo with different encoding

Visual Languages

- Conversation shifts to data visualization techniques that depend on and leverage context, using the concept of a symbolic language to reveal what is possible outside of prebuilt graphics.

12	Lupi and Posavec (2015)	- The concept of movements (Harris and Kamvar 2015) - A dissection of Podcast Anthropology (Pottinger 2015)	- Draw your day - Draw your last 5 years - Draw it again a different way - [Due 13] Draw your next 5 years

Maps

- So far, we've only looked at space metaphorically with symbolic analogy: horizontal position as age and vertical position as salary. However, this conception of information design ignores one of the most foundational data representations out there: maps. This next step considers geographic data and options for plotting.

13	Why all world maps are wrong (Harris 2016)	- Geographic formats - QGIS - Projections	- Draw the Bay Area - Draw BART stations - Draw ridership - [Due 14] Draw weekend vs weekday

Networks

- Like geographic data, network information is often one of the more difficult data types to plot. We turn to some common approaches, explore open source options, and see how geographic networks can be considered.

14	15 Views on a Node Link Graph (Munzner 2007)	- Gephi - Sanky - Arc - Chord	- Memorizing the location of stations - Drawing between stations - Revealing traffic - [Due 15] Draw weekend vs weekday.

Practice

30 points

- Before turning to interactivity, we will pause to collect and visualize some data in a studio-like setting, offering a chance to practice some of the concepts introduced so far.

Day	Reading	Material	Exercise [& Homework]
Making Space			
A discussion of common places to find data and licenses as well as an overview of this movement.			
15	Copyright, Exceptions, and Fair Use (Muller 2015)	- Scraping - Creative Commons - OpenRefine - Overview practice project	- Clean up the BART data - [Due 18] Choose and visualize a dataset.
Sketching			
Explore ideas quickly, practicing with your own data.			
16	Agile is Dead (Thomas 2015)	Software engineering lifecycle	Coding help
Iterating			
Discussion of how to iterate to a final product			
17	Ben Fry (2016)	- Alt text - Reproduceibility - Licensing your own work	Coding help

Responses

60 points

- Before exploring visual languages, we experiment with different visual forms and, practically, how to draw with data in digital media using different libraries.

Day	Reading	Material	Exercise [& Homework]
The reader			
We look at dialetic, the 3 waves of human-computer interaction, covering key concepts such as affordances, social actors, working memory, and coordination.			
18	It's Not You, Bad Doors are Everywhere (Posner et al 2016)	- History of HCI (Duarte and Baranauskas 2016) - Concepts: affordances (Norman 2013), working memory (Ware 2021), social actors (Nass et al 1994)	What is the Dialectic (Guignion 2020)
The Role of the Reader			
So far, we've only looked at space metaphorically with symbolic analogy: horizontal position as age and vertical position as salary. However, this conception of information design ignores one of the most foundational data representations out there: maps. This next step considers geographic data and options for plotting.			
19	- The Role of the Player (Portnow 2011) - Explorable Explanations (Victor 2011)	- Why game design and its role. - Thinking and play	- Load and draw ridership outside a map - Interact with ridership - Coordinated scrubbing - [Due 20] Add another month
Meeting the Player			
Entering into this landscape of different takes who the user is and how they operate, we turn to game design.			
20	Super Mario Bros: Level 1-1: How Super Mario Mastered Level Design (Emmons and Portnow 2014)	- The PLATO system (Bitzer et al 1961) - Tutorialization - Hayashida level design (Pottinger and Zarpelleon 2023)	[Due 22] Write on experience of one of the games*
Ludonarrative			
Thus far, we've considered the player as a logical actor of inputs and outputs. What is their emotional experience of data? How can video games guide us in unlocking pathos?			
21	The Last Guardian and the Language of Games (Brown 2017)	- Ethos, pathos, logos - Gun Detahs (Periscopic 2018) - Bussed out visualization (Bremer and Wu 2017)	Parable of the Polygons (Hart and Case 2014)
Architecture			
With the elements of an interactive experience in place, we turn to various forms of level design.			
22	- Triangle Design (Brown 2023) - Banjo-Kazooie (Brown 2023)	- Loops (Brazie 2024) - AFSC GAP (Pottinger and Zarpelleon 2023) - Ag (Pottinger et al 2024) - Plastics (Pottinger et al 2024)	Share experiences of games*

* Cosmic Wheel (Deconstructteam 2023), FTL (Ma and Davis 2012), Spiritfarer (Thunder Lotus 2020), Papers Please (Pope 2013), Unpacking (Brier and Dawson 2021)

Context

50 points

- With all of the pieces in place for interactive data, we start to develop these ideas beyond the canvas, situating them in a broader design, ethical, social, and technological landscape.

Day	Reading	Material	Exercise [& Homework]
Diegesis			
23	Storytelling with Verbs (Tremblay 2020)	- Diegesis in games (Dassler and Portnow 2019) - APH visualization (Pottinger et al 2024)	- Revisiting BART - Add button for time - Add button for station - [Due 24] Add non-digetic summary to buttons
Looking Ahead			
24	The World Design of Metroid 1 and Zero Mission (Brown 2018)	- Inquiry-based design (Hayes 2023) - Overview of datasets - Journey mapping	- Ag tool (Pottinger 2024) - Journey map - Find your path - [Due 25] Map your final
Measurement and Evaluation			
25	Designing for Realtime Spacecraft Operations (Binx 2016)	- Quantitative (Munzner 2014) - Thinking-Aloud (Lewis 1982) - Diary studies (Chneiderman and Plaisant 2006) - Participatory Design (IxDF 2023) - Generalizable knoweldge vs quality assurance	- Share final experiences of games - [Due 26] Eval plan for final
Accessibility			
26	Games are for Everybody (Brown 2018)	- WCAG - Common patterns - When visual isn't available	[Due 27] Accessibility plan for final
Ethics			
27	Here's What Ethical AI Really Means (Thorne 2023) or Sasha Costanza-Chock (2019)	- Example: User-Centered Machine Learning (Pottinger 2019) - Return to Participatory Design	[Due 28] Ethical reflection on plan for final

Simulations

40 points

So far, this course has focused on information visualization but there's another flavor of interactive data out there: scientific visualization. This offers a brief introduction on how to apply the concepts learned so far towards the other side of this coin through simulation examples.

Day	Reading	Material	Exercise [& Homework]

Thinking Toys

Simulations already appear in a number of video games and we start by taking a look at what scientific simulation and Montessori have in common.

28	Spore, birth of a game (Wright 2007)	- Scientific Viz (Rhyne 2003) - Visualization for Systems Design (Pottinger 2022)	- FoodSim SF - [Due 29] SimCity 3000 or Roller Coaster Tycoon

Magnets

Ready to make our first simulation, we look at defining the forces in a system using an agent-based model and what happens when the user can modify those forces.

29	- When SimCity got serious (Salvador 2020) - Explorable Explanations (Victor 2011)	- Time and physics in sims - Defining a physical system - Interaction on parameters	- Define node link system - Animate - Add diegetic interaction - [Due 30] Add non-diegetic interaction for changing force

Birds

Continuing onwards from magnets, we turn our sights to the Boids algorithm as a more practical example.

30	Emergence (Radiolab 2007)	- Formalizing agent-based models - Defining Boids (Reynolds 1987)	- Define the boids - Antimate the system - Interact non- diegetically (repel) - [Due 31] Add diegetic interaction

Ants

Not everyone experiences the world the same way. We turn to standards and principles to help everyone experience your work.

31	A Gentle Introduction to Markov Chain Monte Carlo for Probability (Brownlee 2019)	- Defining ants - Defining food - Defining pheremones	- Define actors - Animate - Food depletion - [Due 32] Add interaction

Generalizing Simulation

What does it mean to be responsible for representing humans or other creatures within visualizations? This lecture explores the burden we carry and the limitations of our own experience.

32	Programming Portals (Appleton 2022)	- Start up funding - Markov Chains - Monte Carlo	Startup Options Bot (Pottinger 2022)

Mastery

70 points

● As our journey concludes, we look towards the final project with a second round of studio time.

Day	Reading	Material	Exercise [& Homework]
Leaving the Sketchbook			
We've spent our time inside the online sketchbook. Let's look at how we might use Sketchingpy elsewhere.			
33	My love letter to Adobe Flash (Owens 2021)	None	- Run static - Run in notebook - Run locally - Run in browser
Plan			
Revisiting your plans for your final visualization, how do you feel? This check in moment allows participants to talk to each other and with the instructor.			
34	None	- Introduce the final again - Share sources of data from instructor	- Final questions - [Due final] Final interactive viz
Design			
High level opportunity to structure each participant's thoughts around their final work			
35	None	Sketching for structure, journey, feelings	- Sketching - Coding / design help
Data			
The next step is to assemble the data for the project.			
36	None	- Revisiting licenses - Revisiting OpenRefine	- Share data + license - Coding help
Sketch			
Start sketching in code			
37	None	- Revisisting data records - Revisiting code structures	- Screenshot - Coding help
Iterate			
Continue sketching in code			
38	None	- Tips from professor - Revisiting QA	- Share screenshot before after - Coding help

Final

- Let's wrap this up.

Day	Reading	Material	Exercise [& Homework]

Look Back

A quick look back at our work together.

Day	Reading	Material	Exercise [& Homework]
39	None	Comprehending, communicating, constructing	- Group share on progress - Coding help

Look Forward

A quick look back at our work together.

Day	Reading	Material	Exercise [& Homework]
40	None	Thank you from instructor	- Group share what we learned - Group share what we want to do with it - Final coding help

Final

We use our final time together during finals week to share our work with each other, celebrate our new tool chest, and experience the diverse interpretations of this curriculum.

Day	Reading	Material	Exercise [& Homework]
41	None	None	Peer sharing in which participants split into two group and have two sessions of presentation (group a shares to group b then visa versa) in a booth setting.

Works Cited

Note that these resources sometimes are discussing other research or literature. This collection is chosen as a good place for students to continue exploring course topics in an accessible and approachable way but may, in some cases, themselves link further to other resources which discuss the topic in greater detail.

Andrews, RJ. “How Florence Nightingale Changed Data Visualization Forever.” Scientific American, August 1, 2022. https://www.scientificamerican.com/article/how-florence-nightingale-changed-data-visualization-forever/.

Appleton, Maggie. “Programming Portals,” October 23, 2022. https://maggieappleton.com/programming-portals.

Binx, Rachel. “Designing for Realtime Spacecraft Operations.” OpenVisConf, 2016. https://www.youtube.com/watch?v=HuYKhSHcRSQ.

Bitzer, D., P. Braunfeld, and W. Lichtenberger. “PLATO: An Automatic Teaching Device.” *IRE Transactions on Education* 4, no. 4 (December 1961): 157–61. https://doi.org/10.1109/TE.1961.4322215.

Brazie, Alexander. “Designing The Core Gameplay Loop: A Beginner’s Guide.” Game Design Skills, March 19, 2024. https://gamedesignskills.com/game-design/core-loops-in-gameplay/.

Bremer, Nadieh, and Shirely Wu. “Bussed out: How America Moves Its Homeless (Visualization).” The Guardian, December 20, 2017. https://www.theguardian.com/us-news/ng-interactive/2017/dec/20/bussed-out-america-moves-homeless-people-country-study.

Brown, Mark. “How Nintendo Solved Zelda’s Open World Problem.” Game Makers Toolkit, May 9, 2023. https://www.youtube.com/watch?v=CZzcVs8tNfE&themeRefresh=1.

———. “Super Mario 3D World’s 4 Step Level Design.” Game Maker’s Toolkit, March 16, 2015. https://www.youtube.com/watch?v=dBmIkEvEBtA.

———. “The Last Guardian and the Language of Games.” Game Maker’s Toolkit, January 9, 2017. https://www.youtube.com/watch?v=Qot5_rMB8Jc.

———. “The World Design of Banjo-Kazooie.” Game Maker’s Toolkit, October 4, 2023. https://www.youtube.com/watch?v=36wclKt4vdk.

———. “The World Design of Metroid 1 and Zero Mission.” Game Maker’s Toolkit, July 31, 2018. https://www.youtube.com/watch?v=kUT60DKaEGc.

Chaudhry, Anjali. “The Power of Simulation for Climate Action: En-ROADS.” *Academy of Management Learning & Education*, October 17, 2023, amle.2023.0187. https://doi.org/10.5465/amle.2023.0187.

Clegg, Brian. “A Beginner’s Guide to Feynman Diagrams.” BBC and Our Media Ltd, November 1, 2021. https://www.sciencefocus.com/science/feynman-diagrams.

Cleveland, William S., and Robert McGill. “Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods.” *Journal of the American Statistical Association* 79, no. 387 (September 1984): 531–54. https://doi.org/10.1080/01621459.1984.10478080.

Dassler, Sam, and James Portnow. “Diegetic UI - Realistic, or Distracting?” Extra Credits, August 14, 2019. https://www.youtube.com/watch?v=-auyB19Mc6U.

Duarte, Emanuel Felipe, and M. Cecília C. Baranauskas. “Revisiting the Three HCI Waves: A Preliminary Discussion on Philosophy of Science and Research Paradigms.” In *Proceedings of the 15th Brazilian Symposium on Human Factors in Computing Systems*, 1–4. São Paulo Brazil: ACM, 2016. https://doi.org/10.1145/3033701.3033740.

Elliot, Kennedy. “39 Studies about Human Perception in 30 Minutes.” OpenVisConf, 2016. https://medium.com/@kennelliott/39-studies-about-human-perception-in-30-minutes-4728f9e31a73.

Emmons, Dan, and James Portnow. “Super Mario Bros: Level 1-1 - How Super Mario Mastered Level Design.” Extra Credits, June 5, 2014. https://www.youtube.com/watch?v=ZH2wGpEZVgE.

Fathom. “No Ceilings: The Full Participation Project.” No Ceilings, 2016. http://www.noceilings.org/.

Felton, Nicholas. “Nicholas Felton - Eyeo Festival 2011.” Eyeo Festival, 2011. https://vimeo.com/27800118.

Fry, Ben. “Eyeo 2016 - Ben Fry.” Eyeo Festival, 2016. https://vimeo.com/175846596.

Gemignani, Zach. “Better Know a Visualization: Small Multiples.” Juice, Inc, January 6, 2021. https://www.juiceanalytics.com/writing/better-know-visualization-small-multiples.

Guignion, David. “What Is the Dialectic? | Plato, Kant, Hegel, Marx.” Occidental College, October 7, 2020. https://www.youtube.com/watch?v=RY_rGJUpwsM.

Harris, Johnathan. “The Web’s Secret Stories.” TED Conference, 2007. https://www.ted.com/talks/jonathan_harris_the_web_s_secret_stories?language=en.

Harris, Johnny, Gina Barton, Alvin Chang, and Phil Edwards. “Why All World Maps Are Wrong.” Vox Media, December 2, 2016. https://www.youtube.com/watch?v=kIID5FDi2JQ.

Harris, Jonathan, and Sep Kamvar. “We Feel Fine,” 2005. http://www.wefeelfine.org/.

Hart, Vi, and Nicky Case. “Parable of the Polygons,” November 7, 2014. https://ncase.me/polygons/.

Hayes, Nicolette. “Data Visualization for Education: When Asking Questions Is the Answer.” Stamen Design, April 26, 2023. https://stamen.com/data-visualization-for-education-when-asking-questions-is-the-answer/.

Hocking, Clint. “Ludonarrative Dissonance in Bioshock.” Click Nothing, October 7, 2007.

Hunter, John, Darren Dale, Eric Firing, Michael Droettboom, and Matplot. “Shared Axes.” Matplotlib, 2024. https://matplotlib.org/stable/gallery/subplots_axes_and_figures/shared_axis_demo.html.

IOM. “Interactive World Migration Report 2024.” International Organization for Migration, 2024. https://worldmigrationreport.iom.int/msite/wmr-2024-interactive/.

IxDF. “What Is Participatory Design?” Interaction Design Foundation, March 17, 2023. https://www.interaction-design.org/literature/topics/participatory-design.

Jason, Brownlee. “A Gentle Introduction to Markov Chain Monte Carlo for Probability.” Guiding Tech Media, September 25, 2019. https://machinelearningmastery.com/markov-chain-monte-carlo-for-probability/.

JM8. “The Secret to Making Any Game Satisfying | Design Delve.” Second Wind, March 15, 2024. https://www.youtube.com/watch?v=ORsb7g_ioLs.

Katz, Josh. “You Draw It: Just How Bad Is the Drug Overdose Epidemic?” The New York Times, October 26, 2017. https://www.nytimes.com/interactive/2017/04/14/upshot/drug-overdose-epidemic-you-draw-it.html.

Keith, David R., Sergey Naumov, and John Sterman. “Driving the Future : A Management Flight Simulator of the US Automobile Market.” *Simulation & Gaming* 48, no. 6 (December 2017): 735–69. https://doi.org/10.1177/1046878117737807.

Kesavan, Vidya. “Preattentive Attributes in Visualization – An Example,” November 17, 2016. https://daydreamingnumbers.com/blog/preattentive-attributes-example/.

LeRoy, Benjamin. “Review of Tufte’s ‘The Visual Display of Quantitative Information,’” May 16, 2018. https://benjaminleroy.github.io/pages/blog/public/post/2018/05/16/review-of-tufte-s-the-visual-display-of-quantitative-information/.

Lewis, Clayton. “Using the ‘Thinking-Aloud’ Method in Cognitive Interface Design.” IBM Research, 1982. https://dominoweb.draco.res.ibm.com/2513e349e05372cc852574ec0051eea4.html.

McDonald, J.H. *Handbook of Biological Statistics*. 3rd ed. Baltimore, Maryland: Sparky House Publishing, 2014. http://www.biostathandbook.com/#print.

Muller, Stan, John Green, Mark Olsen, Frank Muller, and Zulaiha Razak. “Copyright, Exceptions, and Fair Use,” May 7, 2015. https://thecrashcourse.com/courses/copyright-exceptions-and-fair-use-crash-course-intellectual-property-3/.

Munzner, Tamara. “15 Views of a Node Link Graph.” Google, October 8, 2007. https://www.youtube.com/watch?v=WOBKnRlOAes.

———. *Visualization Analysis and Design*. A.K. Peters Visualization Series. Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2015.

Owens, Matt. “My Love Letter to Adobe Flash.” UX Collective, January 5, 2021. https://uxdesign.cc/my-love-letter-to-adobe-flash-8166ec03f10b.

Perisocopic. “U.S. Gun Deaths,” 2018. https://guns.periscopic.com/.

Portnow, James. “The Role of the Player.” Extra Credits, June 15, 2011. https://www.youtube.com/watch?v=1XlfeXpiSuQ.

Posner, Joe, Roman Mars, Don Norman, and Gina Barton. “It’s Not You. Bad Doors Are Everywhere.” Vox Media, February 26, 2016. https://www.youtube.com/watch?v=yY96hTb8WgI.
Pottinger, A. “Economic Health and Political Balance,” 2012. https://gleap.org/content/economic_health.
———. “Podcast Anthropology,” 2015. https://gleap.org/static/special/podcast_viz/index.html.
———. “Startup Options Bot,” 2022. https://startupoptionsbot.com.
———. “Thinking Through Visualization Tools.” Vimeo, March 28, 2203. https://vimeo.com/812607645.
———. “User Centered Machine Learning,” March 11, 2019. https://www.slideshare.net/Samnsparky/user-centered-data-science-135680883.
———. “Visualizing for Systems,” 2022. https://gleap.org/content/visualizingForSystems.
———. “What Are the Happiest Jobs in Tech?” Towards Data Science, August 19, 2019. https://towardsdatascience.com/what-are-the-happiest-jobs-in-tech-4c4d33e065f0.
Pottinger, A Samuel, Nivedita Biyani, Roland Geyer, Douglas J McCauley, Magali de Bruyn, Molly R Morse, Neil Nathan, Kevin Koy, and Ciera Martinez. “Combining Game Design and Data Visualization to Inform Plastics Policy: Fostering Collaboration between Science, Decision-Makers, and Artificial Intelligence,” 2023. https://doi.org/10.48550/ARXIV.2312.11359.
Pottinger, A Samuel, and Giulia Zarpellon. “Pyafscgap.Org: Open Source Multi-Modal Python-Basedtools for NOAA AFSC RACE GAP.” *Journal of Open Source Software* 8, no. 86 (June 28, 2023): 5593. https://doi.org/10.21105/joss.05593.
Pricenomics. “How William Cleveland Turned Data Visualization Into a Science.” Udemy, January 6, 2016. https://priceonomics.com/how-william-cleveland-turned-data-visualization/.
Rachel, Binx. “Designing for Realtime Spacecraft Operations - Rachel Binx.” OpenVisConf, 2016. https://www.youtube.com/watch?v=HuYKhSHcRSQ.
Radiolab. “Emergence.” WNYC Studios, August 14, 2007. https://radiolab.org/podcast/91500-emergence.
Rendgen, Sandra. “Historical Infographics: From Paris with Love.” Wordpress, March 15, 2019. https://sandrarendgen.wordpress.com/2019/03/15/data-trails-from-paris-with-love/.
Reynolds, Craig W. “Flocks, Herds, and Schools: A Distributed Behavioral Model.” In *Seminal Graphics*, 273–82. New York, NY, USA: ACM, 1998. https://doi.org/10.1145/280811.281008.
Rhyne, Theresa-Marie. “Does the Difference between Information and Scientific Visualization Really Matter?” *IEEE Computer Graphics and Applications* 23, no. 3 (May 2003): 6–8. https://doi.org/10.1109/MCG.2003.1198256.
Rogers, Simon. “John Snow’s Data Journalism: The Cholera Map That Changed the World.” The Guardian, March 15, 2023. https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map.

Salvador, Phil. “When SimCity Got Serious: The Story of Maxis Business Simulations and SimRefinery.” The Obscuritory, May 19, 2020. https://obscuritory.com/sim/when-simcity-got-serious/.

Sasha, Costanza-Chock. “Eyeo 2019 - Sasha Costanza-Chock.” Eyeo Festival, 2019. https://vimeo.com/354276956.

Shneiderman, Ben, and Catherine Plaisant. “Strategies for Evaluating Information Visualization Tools: Multi-Dimensional in-Depth Long-Term Case Studies.” In *Proceedings of the 2006 AVI Workshop on BEyond Time and Errors: Novel Evaluation Methods for Information Visualization*, 1–7. Venice Italy: ACM, 2006. https://doi.org/10.1145/1168149.1168158.

Swaroop, CH. “A Byte of Python,” 2023.

Tero, Atsushi, Seiji Takagi, Tetsu Saigusa, Kentaro Ito, Dan P. Bebber, Mark D. Fricker, Kenji Yumiki, Ryo Kobayashi, and Toshiyuki Nakagaki. “Rules for Biologically Inspired Adaptive Network Design.” *Science* 327, no. 5964 (January 22, 2010): 439–42. https://doi.org/10.1126/science.1177894.

Thomas, Dave. “Agile Is Dead.” GOTO, 2015.

Thorne, Abigail. “Here’s What Ethical AI Really Means.” Philosophy Tube, October 13, 2023. https://www.youtube.com/watch?v=AaU6tI2pb3M.

Tremblay, Kaitlin. “Storytelling with Verbs: Integrating Gameplay and Narrative.” GDC, March 17, 2020. https://www.youtube.com/watch?v=ontNUxSLhb8.

Tufte, Edward R. *The Visual Display of Quantitative Information*. 2nd ed., 8th print. Cheshire, Conn: Graphics Press, 2013.

Victor, Bret. “Explorable Explanations.” Bret Victor, March 10, 2011. http://worrydream.com/ExplorableExplanations/.

———. “Inventing on Principle.” CUSEC, 2012. https://www.youtube.com/watch?v=PUv66718DII.

———. “Media for Thinking the Unthinkable.” MIT Media Lab, April 4, 2013. https://vimeo.com/67076984.

Ware, Colin. *Information Visualization: Perception for Design*. Fourth edition. Cambridge, MA: Morgan Kaufmann, Inc, 2021.

Wright, Will. “Spore, Birth of a Game.” TED Conference, March 2007. https://www.ted.com/talks/will_wright_spore_birth_of_a_game?language=en.

Other information

This report uses colors from Color Brewer 2.0:

Brewer, Cynthia, Mark Harrower, Ben Sheesley, Andy Woodruff, and David Heyman. “ColorBrewer 2.0.” The Pennsylvania State University, 2013.