data visualization

SARC 5400
T 7:00-9:30pm Campbell Hall 153 Eric Field [emfield@virginia.edu]

In September 1854, London experienced a severe epidemic of cholera. By creating graphics that mapped the information available in a clear and spatial manner, Dr. John Snow was able to identify the cause and stop the disease.[1]
In January 1986, the space shuttle Challenger exploded during launch due to a failure of O-rings under low temperature. Had the data — which was available — simply been presented differently, the launch may arguably not have occured, saving the craft and crew.[1]
This is a class about information and data visualization.

We live in a world rich with information. This course concentrates on the identity and role of information in our environs: in language; in science, medicine, economics, art, politics; in the buildings and cities that we inhabit; in our expanding communications networks; and in the tools and technologies we create to help us navigate, understand, and collaborate on the problems that we face.

Science and technology, including the building sciences, environmental sciences, and political sciences, make a ton of information available to us. We can model, map, and simulate almost anything, and produce multitudes of data.

But most of us don't understand `data`. We need to see it. We need to visualize it — contextualize it, draw its relationships, and envision the scenarios surrounding it — to make effective decisions. Too often, though data is available, we don't use it or misuse it, because it lacks context and meaning to understand. We understand better if we make it visual.

This class is about using visual and spatial thinking to construct information — to find, indeed invent, approaches toward seeing, envisioning, and understanding — to make better informed decisions about the problems of our world. To do this we will study — and make — useful, compelling, and beautiful data visualizations.

With a dual focus on content and craft, this course will look both theoretically and practically at how we build information, why, and how we use it and populate it in our world. We will study language, graphics, and urban form as dialects of `information space`, while we learn and experiment with both existing visualization software and custom interactive web programming as vehicles to build new architectures and interfaces that use, visualize, and analyze information well.

At the end of the semester, each student will take on a case study using their own data for a final visualization project, using data from natural, scientific, economic, cultural, and/or human-behavioral pressures. Projects will produce and extract insight from visualizations built from this data, using the tools of the class.

Through this class, we will develop techniques and tools to see and understand complex issues at multiple scales, to effect change and create impact.

Thinking with Images.

[1] Edward Tufte, *Visual Explanations*
image from Snow, John, On the Mode of Communication of Cholera (London, 1855), reproduced in Tufte, Edward, Visual Explanations, pp. 30-31

sarc5400

3 credits
Spring 2023
Tuesday 7:00-9:30pm
Eric Field

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Date	Topic	Assignments / Exercises
PART I : INFORMATION AS A CONSTRUCTION		
January 24	**Introductions** - Visual Data / Visual Problem Solving - `1+1=3` - Using and Building Visualization Tools - Semester Goals and Contexts **Language, Graphics, and Communication** - Re-thinking how we see to communicate - Means of communication - speak, write, draw, gesture - Graphics, Signs, Symbols, and Icons - Ideograms and the Language of Symbols - Braille, Morse Code, Sign, and Gesture - Diagrams of Language - Music and Dance Notation - Graphic Inventions	***Assignment I*** - *the Good, the Bad, and the Ugly* *(due Jan. 31)* *Reading* - - The Design of Everyday Things, Preface, Norman - Visual and Statistical Thinking, Tufte
January 31	**Review - the Good, the Bad, and the Ugly** - *In-class presentations and discussion* **Tools for Graphic and Data Description** - Describing the display of information - Adobe Illustrator: Objects with Properties	*- peer review -* ***Assignment II*** - *Me, graphically* *(due Feb. 14)* *Task* - Install Adobe Illustrator or Inkscape
February 7	**The Material of Information** - The Five Senses (and how we use them) - Information Mapping and Recording - Cognitive Load Theory: too much information? - Elements of Differentiation **Structuring Information Objects** - Meta languages: Illustrator, SVG, HTML - Basic object description - Writing Code: Objects with Properties - Collecting Properties - Cascading Style Sheets - [Observable] and live notebook coding - A preview of D3: Data Driven Documents	*Task:* Setup Observable Browse Observable tutorials office hours: Adobe Illustrator / Inkscape
February 14	**Review - Me, graphically / the quantified self** - *In-class presentations and discussion* **Visualization Tools for Data** - RAW - "the missing link between spreadsheets and data visualization" - Tableau - "visual analytics for everyone" - capacities and limitations	*- peer review -* ***Assignment III*** - *Visual Data Analysis* *(due Feb. 28)*

February 21	**Visual Literacy / Escaping Flatland** - Coding and Decoding - How people experience and understand - Color - Time - Statistics, Graphs, Maps, and Diagrams - Edward Tufte & The Grand Principles of Analytic Design - Visualization types, techniques, and examples **Seeing into Complexity** - more Tableau - "Show Me" - visual order and strategy - Visual Hierarchy - The 'squinty eye test' - Custom measures - Layering data - Combining visual approaches	*Reading -* - Escaping Flatland, Tufte - How to Look at Color, Elkins - How to Look at the Periodic Table, Elkins *Reference -* - Graphic Methods for Presenting Facts, Brinton office hours: RAW / Tableau
February 28	**Review - Visual Data Analysis** - *In-class review and discussion* **Building a Custom Data Visual** - Intro to D3 - Data-driven graphics	*- peer review -* *Technical Exercise -* *Land guzzlers: Constructing Visual Order* office hours: code / D3 / Observable
March 7	***Spring Break*** *- no class*	
PART II : INFORMATION AS AN AGENT		
March 14	**Seeing into Problems / Interactive Information Systems** - Games, Data Interfaces, and Complex Problems - Seeing into Systems - Visual Analytics for Problem Solving? **Big Data / Encoding the Structure of a Visualization** - "Drawing" Insight - Encoding large datasets, visually - Data formats, reading, parsing - the Powerplants exercise	***Assignment IV*** *-* *Between Things* *(due Mar. 28)* office hours: Data to Visual Encoding
March 21	**Storytelling - getting *'between things'*** - Asking questions, of data, through diagramming - Telling a story through data - Visual insight **Interaction and Dynamics - making things move** - Interaction modes and concepts - D3, Observable, and dynamics - Building an interactive visual	*Reading -* - Make it so: Interaction Design Lessons from Science Fiction, Wired *Reference -* - Designing Interactions, Moggridge
March 28	**Review - Between Things** - *In-class review and discussion* **the Data in D3** - dynamics for data insight - Dynamic data - joins and the automatic updating visual - Data manipulations, groups, aggregations, hierarchies - Layers, filters, intersections - visual analytic approaches - data => interactivity - more Powerplants	*- peer review -* ***Final Project, Part I*** *-* *Ugly Sketch & Prototype* *(due Apr. 11)*

April 4	**Maps and Geospatial Visualization** – Maps and Mapping – views, context, and grammar – Encoding and recording place – D3 GeoJSON – Map APIs (Mapbox)	*Reading –* – How to Look at a Map, Elkins office hours: Data – finding, cleaning, preparing
April 11	**Workshopping Review – Project Prototypes** – *presentations and discussion of prototype visualizations* **D3 Layout Engine** – an array of common visual types in D3 – dvlib and packaged routines (like RAW, but in D3) – Network diagrams, Cluster layouts, Packed Bubbles, etc.	*– peer review –* ***Final Project**:* *Visualizing Complexity*
April 18	**Wicked Problems / Visualization Challenges**: – A position on visualization – Some Examples **Workshopping Review – more Project Prototypes (ongoing)** – Interim review of your mock-ups, trials, approaches, progress – Technical / Topical challenges and solutions **Workflows – Passing things between tools** – Illustrator to SVG to D3; RAW to D3; Tableau to Illustrator; … – Quicker ways to get things done.	*Individual Meetings*
April 25	**Workshopping Review – more Project Prototypes (ongoing)** – more mock-ups, trials, approaches, progress – Technical / Topical challenges and solutions **More Workflows – Approaches / Refinements / Q&A** – Quicker ways to get things done. – Extractions – The whole visualization	*Individual Meetings*
May 2	**Spatial Interfaces** – Orientation and Organization – Finding your way – Space, Place, and Information – A technical and cultural history of `information space` – Human Interface **Semester wrap-up / Conclusions** – Gehry's squiggle – Hierarchy of Visual Understanding? – Syn(thesis) – "Thinking with Images".	*Individual Meetings*
May XX – TBD	**Final Project Public Showcase Event**, during finals week	

Instructor

Eric Field, emfield@virginia.edu, 206 Peyton House, 434.924.4033

TAs

Tina Chen, Computer Science / Cognitive Science, tc7nz@virginia.edu
Michelle Tran, Architecture, mlt4em@virginia.edu
others TBD

Office Hours – for any kind of question, help, idea, or you just want to talk over a thought.

Days and times TBD based on class survey, and will be posted on the Canvas site.

Course Objectives

Experience and understand how visual and spatial thinking is part of how humans see into problems.
Learn theories, techniques, strategies, and tools for constructing information visually.
Try, Stretch, Exercise, and Explore the use of tools and strategies for visualizing data.
Critically synthesize the theory and practical application of visualization for problem solving.
Develop an iterative approach to evolve and test visualization and problem-solving methods.
Produce compelling and useful data visualizations.
Extract Insight.
Have Fun!

Assignments and Grading

Grading is a mechanism for feedback and discussion about individual work.
Final grades in the course will be determined based on a variety of factors, including performance on assignments, class participation and contribution, and an individual assessment of what and how each student has learned, progressed, and grown through the semester. It is not just a calculation.

Assignment weightings:

Assignment I:	5%
Assignments II, III, IV (each):	10%
Technical Exercises:	10%
Final Project:	40%
Peer Review:	5%
Participation and Contribution:	10%

Grading measure / descriptions:

5 Excellent work. Reflects outstanding achievement in both content and execution.
Work must far surpass the given requirements.
Extends concepts and demonstrates effort and inquiry that pushes concepts toward insight.

4 Good work. Reflects high achievement in both content and execution, and must excel beyond given requirements.
"Gets it" and accomplishes work that demonstrates good understanding of concepts.

3 Base-level work. Basically gets it, but work could improve and lacks deep effort or serious understanding. For Graduate students, this is inadequate and does not fulfill requirements.
For Undergraduate students, this is passing but minimal.

2 Poor work. Struggling to meet criteria, needs extra attention. Does not fulfill requirements.

1 Completed something, but seriously deficient. Fulfills few, if any, requirements.

0 Didn't even turn it in.

Across the semester, a 4.5 average will achieve a solid A in the course.

Late work:
All assignments are due on time, generally at the start of class on Tuesday, 7pm.
0.5 point will be taken off for work that is considered late without reasonable reason.
More may be taken off for extended lateness.
Exceptions and extensions for medical, family, or other circumstances may be granted. Contact me.

For Graduate Students: B- is the minimum passing grade.

Attendance (see School of Architecture Attendance and Excused Absences policies below)

Physical and intellectual presence is expected during class meeting times. This includes participation during in-class assignment reviews. Certainly, circumstances may occur that prevent occasional attendance. Please let me know. Excessive and especially unexcused absence will impact grading.

Accommodation, Trouble, and Support (see School of Architecture policies below)

If you need assistance, special accommodation, or at any point feel that you need help, support, or to discuss or report any form of incident or issue, please contact or come talk to me.

Honor (see School of Architecture Honor policy below)

The University's Honor principle that students will not lie, cheat, or steal, nor tolerate those who do, applies fully in this class. Your work will be your own.
Collaborative learning, idea sharing, helping others, and the sharing of techniques and even code is fully allowed and indeed expected as part of the learning environment of the class. Copying techniques, including other people's technical code (especially from web sources), is fully allowed, part of learning, and not a breach of Honor, *as long as* it is not the entire project, and it is cited. It is the implementation and outcome of your work that is your own.

Materials

For this class, you will need:

- your eyes
- your brain
- your computer (a full regular computer that can run normal software, Mac or Windows)
- a pen, pencil, or other similar drawing implement(s), and something to draw on (can be electronic)

Recommended for your laptop

These tools will be used throughout the semester. Most are available in the A-School and in libraries, including Fine Arts, Clemons, Music, and Alderman's Scholar's Lab.

- **Adobe Illustrator** ($99 Student License Program (SLP), through Cavalier Computers)
    - You can also get it for $31.49 /mo. through Adobe, but for the semester, that's more than the $99 price for the entire Adobe suite through June.
    - Note that using Adobe CC products in the A-School requires a personal license to login. Using them on Library computers is free and open use.

- **Inkscape**. Optional open-source alternative to Adobe Illustrator. Not as stable, but free.
- **Tableau Desktop** and **Tableau Prep Builder**. Free student license and download.
- **Observable**. Web-browser-based interactive notebook coding platform. Free.
    - You can also do much of this with a code editor like Visual Studio Code, but we'll be concentrating on the interactiveness of Observable.

Books and Readings

All readings are posted on Canvas. There are no required books to purchase.

Four books by Edward Tufte are on reserve at the Fine Arts Library, under this course. (see below)
* fully browsable online links to some of these can also be found in Canvas under Readings.

If you are interested to purchase a book about Visualizing Data, the one that I recommend is:

Tufte, Edward. **Envisioning Information**. Cheshire, CT: Graphics Press, 1990.

Other books in this series that are on reserve include:
Tufte, Edward. **The Visual Display of Quantitative Information**. Cheshire, CT: Graphics Press, 1983.
Tufte, Edward. **Visual Explanations**. Cheshire, CT: Graphics Press, 1997.
Tufte, Edward. **Beautiful Evidence**. Cheshire, CT: Graphics Press, 2006.

Sources for other readings can be found on Canvas, under Files > Readings.

Beware of books about visualization that have very few graphics in them. (You'd be surprised how many there actually are like this.) The benefit of the Tufte books above is that they are very browsable and full of visualizations, with text as critical explanation, comparison, and support.
Don't tell me how to visualize. Show me.

School of Architecture Academic Policies

Class Attendance

Regular attendance in classes is a vital part of the educational process and is expected throughout the semester. At the University of Virginia, students are expected to accept the responsibility of attending classes regularly and promptly.

Unexcused absences will seriously hinder achievement in the class. A student who is making no real progress in class, or whose behavior is detracting from the class, may be excluded from the course by the instructor with a grade of W or F. Students have five calendar days following written notification of this exclusion in which to appeal to the Chair of the department or program offering the class. The appeal may then, at the student's request, be considered by the Associate Dean for Academics of the School. Until the final disposition of the appeal, the student is considered enrolled in the class and may continue to attend classes with the approval of the instructor and the Associate Dean for Academics.

Students may not attend classes in which they are not enrolled, nor may they bring guests to classes in which they are enrolled, without the permission of the instructor. Students must be enrolled in the class by the School of Architecture's add deadline; students cancelled who miss this deadline must wait until the following term to return.

Instructors may refer to the Associate Dean of Academics any student whose attendance record they consider unsatisfactory. The dean's office, upon request from a faculty member, may disenroll a student with a grade of W. Once the class withdrawal deadline passes, the instructor may ask that the student be removed from the class and a grade of F will be assigned.

Neither the Department of Student Health nor the School of Architecture Dean's office issues excuses for class absence or for missed assignments. Only the instructor, not the Association Dean for Academics, can determine if the student can make up missed work.

Note: The instructor may drop a student from their class who is not in attendance on the first day of the semester.

Excused Absences

Absences traditionally excused are the following: hospitalization, serious illness, death in the family, important religious holidays (see http://uvapolicy.virginia.edu/policy/PROV-008#Academic_Accommodation_for_Religious_Observance for Provost's policy), and authorized University activities (field trips, University-sponsored athletic events). Students who anticipate absence for cause should obtain permission from the instructor in advance of the absence. Unforeseen absences resulting from sickness, or from other circumstances considered to be emergencies, may be excused by the instructor and arrangements may be made with the instructor to complete the assignments missed.

Assignment Deadlines

All assignment deadlines listed in the syllabus and/or in course handouts are final.

Extensions

Individual requests for extensions due to medical emergencies or family circumstances are to be discussed with the instructor. The utmost discretion protecting your privacy will be assured. The final decision for any extension requests and post-review schedule to complete work for grading purposes will be made by the instructor.

Extensions for Medical Reasons

Concerning medical circumstances/emergencies, safely attending to the medical circumstance/emergency is the first and foremost priority. A request for a deadline extension due to a medical emergency should be submitted only after the emergency has been safely and properly addressed. A request for a deadline extension due to a medical reason should be submitted in writing by the student to the instructor. The deadline extension request must include an official note from a physician and a schedule specifying the completion date of the assignment.

Extensions for Family Circumstances
A request for a deadline extension due to a family circumstance should be submitted in writing to the instructor. The deadline extension request must include a note signed by the student explaining the reason for the extension request and a schedule specifying the completion date of the assignment.

SARC End-of-Semester Extension of Time ("Incomplete")
A grade of "Incomplete" (IN) is to be granted only in cases due to medical emergencies and circumstances or family situations that necessitate additional time to complete course work. A request for an extension is to be submitted to the **Student Services Office** (CAM 201) prior to the last day of class using the "Extension of Time" form approved by the Associate Dean of Academics. An 'IN' is not considered a valid default final grade and will convert to a grade of 'F' five days after the end of the examination period unless an "Extension of Time" form is submitted by the course professor with the approval of the Associate Dean for Academics. Documentation supporting the medical excuse is to be provided by a doctor or healthcare provider with the "Extension of Time" form. Additionally, a workplan outlining the scope and extended deadline for completion of coursework is due to the Associate Dean of Academics at the time of the form submittal. An approved grade of 'IN' will convert automatically to a grade of 'F' four weeks after the end of the examination period, unless the professor submits a final grade based on the work completed under the extension or a workplan identifying a specific date for completion of course work. Instructors are not authorized to extend the time for completion of course work without the approval of the Associate Dean of Academics. "Extension of Time" forms for extension approval are available in the Student Services Office, 201 Campbell Hall

Student Safety
The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that the faculty, the University, and we hold as critically important:

1. Power-based personal violence will not be tolerated.
2. Everyone has a responsibility to do their part to maintain a safe community on Grounds.

If you or someone you know has been affected by power-based personal violence, more information can be found on the **Office for Equal Opportunity and Civil Rights** website that describes reporting options and resources available and direct access to the **Report and Incident** tool.

As your professors, know that we care about your wellbeing and stand ready to provide support and resources as we can. As faculty members, we are responsible employees, which means that we are required by University policy and federal law to report what you tell us to the University's EOCR and/or Title IX coordinators. The coordinators' commitment is to ensure that the reporting student receives the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community.

Students in Distress
Services for students in various forms of distress are offered by Counseling and Psychological Services (https://www.studenthealth.virginia.edu/caps) in the Elson Student Health Center. During evenings and weekends, emergency crisis assistance (**434.972.7004**) is available. In addition, if you are concerned about another student, call **434.243.5150** during business hours, and request the consulting clinician.

Special Needs
It is the policy of the University of Virginia to accommodate students with disabilities in accordance with federal and state laws. Any student with a disability who needs accommodation (e.g., in arrangements for seating, extended time for examinations, or note taking, etc.), should contact the **Student Disability Access Center (SDAC)** and provide them with appropriate medical or psychological documentation of his/her condition. Once accommodations are approved, it is the student's responsibility to follow up with the instructor about logistics and implementation of accommodations.

If students have difficulty accessing any part of the course materials or activities for this class, they should contact the instructor immediately. Accommodations for test taking should be arranged at least 14 business

days in advance of the date of the test(s). Students with disabilities are encouraged to contact the SDAC: 434.243.5180 (Fax: 434.243.5188); Email: SDAC@Virginia.edu; https://www.studenthealth.virginia.edu/sdac.

The Honor System and the School of Architecture
The School of Architecture relies upon and cherishes its community of trust. We firmly endorse, uphold, and embrace the University's Honor principle that students will not lie, cheat, or steal, nor shall they tolerate those who do. We recognize that even one honor infraction can destroy an exemplary reputation that has taken years to build. Acting in a manner consistent with the principles of honor will benefit every member of the community both while enrolled in the School of Architecture and in the future. It is assumed that students work together in a spirit of collaborative learning in class. You are encouraged to ask for advice from your classmates and other students, and offer the same for them.

All work should be pledged in the spirit of the Honor System of the University of Virginia. The instructor will indicate which assignments and activities are to be done individually and which permit collaboration. The following pledge should be written out at the end of all quizzes, examinations, individual assignments and papers: "I pledge that I have neither given nor received help on this examination (quiz, assignment, etc.)". The pledge must be signed by the student.

The Honor Code is enforced by the Student Honor Committee which makes determinations of guilt or innocence based on three criteria, 1) whether the alleged act occurred, 2) its intentionality, and 3) its non-triviality. Students found to have violated the Honor Code are expelled from the University of Virginia following one single violation.

If you have questions about the University of Virginia Honor Code please contact the School's representatives or call the Honor offices **at 434.924.7602**. In addition, you may find more information at http://www.virginia.edu/honor/. If you have questions about special cases in the context of the School of Architecture's curriculum, contact your academic advisor.

Classroom Civility Statement / Use of Devices in the Classroom
Students are asked to refrain from conducting private conversations (both in-person and electronically) in class, and are requested to use appropriate language and behavior that are not demeaning or disruptive to either the instructor or the other members of the class. No use of electronic devices in the classroom is permitted without the permission of the instructor. This means laptops, phones, I-Pads, etc. Using these devices without permission from the instructor will be considered disruptive behavior and could result in the withdrawal of the student from the course. Instructors may permit their use on specified days, when they are needed for class exercises or in-class work. Otherwise, such devices should not be in use during class time. Recording devices are exempt from this policy.

Recording of Class Sessions
Additionally, as the class is being recorded in order to facilitate learning by those unable to join us synchronously, students must agree to not "clip" parts of the class and disseminate in social media or via other methods. We want to be able to have frank and interesting conversations; these might touch upon sensitive topics and we need to feel free to express ourselves and trust those with whom we are speaking. If you are found to have violated this rule, I will consider it an infraction worthy of being reported to the Student Honor Committee as it violates the "community of trust" objective. Please don't do it.

Please consider the following alternative policy statements:
Guidance for Implementing Recording of Class Sessions and Distribution of Course Materials.

Full policy on Recording of Class Sessions and Distribution of Course Materials

University Email Policy
Students are expected to activate and then check their official UVA email addresses on a frequent and consistent basis to remain informed of University communications, as certain communications may be time sensitive. Students who fail to check their email on a regular basis are responsible for any resulting consequences.