Tufte’s Design Principles

CS 7450 - Information Visualization
September 17, 2012
John Stasko

Today’s Agenda

Edward Tufte has written seven books, including Visual Explanations, Envisioning Information, The Visual Display of Quantitative Information, and Data Analysis for Politics and Policy. He writes, designs, and self-publishes his books on analytical design, which have received more than 40 awards for content and design. He is Professor Emeritus at Yale University, where he taught courses in statistical evidence, information design, and interface design. His current work includes landscape sculpture, pointmaking, video and a new book.

This website describes Edward Tufte’s books, one-day course, and artwork. For further information, call Graphics Press at 203-272-9127, or fax 203-272-5000, or email. For a moderated forum on analytical design, go to Ask ET.
Graphical Excellence

• Principles
  – Graphical excellence is the well-designed presentation of interesting data---a matter of substance, of statistics, and of design
  – Graphical excellence consists of complex ideas communicated with clarity, precision and efficiency

According to Tufte

Graphical Excellence

• Principles
  – Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
  – Graphical excellence is nearly always multivariate
  – And graphical excellence requires telling the truth about the data
Leveraging Human Capabilities

- Data graphics should complement what humans do well

“We thrive in information-thick worlds because of our marvelous and everyday capacities to select, edit, single out, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, list, abstract, scan, look over, sort, integrate, blend, inspect, filter, lump, skip, smooth, chunk, average, approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flop through, browse, glance into, leaf through, skim, refine, enumerate, glean, synopsize, winnow the wheat from the chaff, and separate the sheep from the goats.” Vol.2, page 50

Summary

- 1. Tell the truth
  - Graphical integrity
- 2. Do it effectively with clarity, precision...
  - Design aesthetics

Let’s look at each of these
1. Graphical Integrity

• Your graphic should tell the truth about your data

Example

Stock market crash?
Chart Integrity

- Where’s baseline?
- What’s scale?
- What’s context?

Vol 1, p. 54 (1)

Where’s 0?
Note middle ‘70
What's being compared?

Scale?
Vol 1, p. 61

Scale?

Vol 1, p. 74

Great work!
Vol 1, p. 74

Ahhhh

Show the context

Local Example

A huge rise?

Atlanta Journal Constitution
Summer '08
More of the data

Atlanta Journal Constitution
Dec. '08

Watch Size Coding

- Height/width vs. area vs. volume
Vol 1, p. 69

area = value?

Vol 1, p. 62

volume = value?
Measuring Misrepresentation

- Visual attribute value should be directly proportional to data attribute value

\[
\text{Lie factor} = \frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}
\]

p.62 \quad 9.4 = \frac{4280}{454}

2. Design Aesthetics

- Set of principles to help guide designers
Design Principles

• Maximize data-ink ratio

\[
\text{Data ink ratio} = \frac{\text{Data ink}}{\text{Total ink used in graphic}}
\]

= proportion of graphic's ink devoted to the non-redundant display of data-information

Vol 1, p. 94

Good        :        Bad
More...

- Above all else, show the data
- Maximize the data-ink ratio
- Erase non-data-ink
- Erase redundant data-ink
- Revise and edit
More...

• Maximize data density

\[
data \text{ density of graphic} = \frac{\text{number of entries in data matrix}}{\text{area of data graphic}}
\]

Quote ...

Maximize Data Density

“Data-rich designs give a context and credibility to statistical evidence. Low-information designs are suspect: what is left out, what is hidden, why are we shown so little? High-density graphics help us to compare parts of the data by displaying much information within the view of the eye: we look at one page at a time and the more on the page, the more effective and comparative our eye can be. The principle, then, is:

Maximize data density and the size of the data matrix, within reason.”

Vol 1, p 168
Redesign charts

- Bar chart, scatter plot, box plot

Bar chart
Box plot

Fall 2012  
CS 7450  
37

Box plot

Fall 2012  
CS 7450  
38
Scatter plot

Fall 2012
CS 7450
41

Scatter plot

Fall 2012
CS 7450
42
Design Principles

• Avoid chartjunk
  – Extraneous visual elements that detract from message

Vol 1, p 108
Vol 2, p.34

A classic

Diamonds Were A Girl's Best Friend

USA Today

Junk Charts Blog

http://junkcharts.typepad.com/

More Thoughts

Great narrative: Vol.2, bottom page 33-34
Rethink That?

Compared plain charts to “embellished” charts

Found that the embellished charts were just as good on interpretation accuracy and were recalled better weeks later

Participants also preferred the embellished ones

Some caveats:
- Very simple data
- Very plain plain charts
- Each chart/data is different

My take: It’s all about purpose

Design Principles

- Utilize multifunctioning graphical elements (macro/micro readings)
  - Graphical elements that convey data information and a design function
US Army Divisions
going to France in
WW I

Leonard P. Ayres
*The War with Germany*
1919
Vol 2, p. 36
Michel E. Turgot
Louis Bretz

Plan de Paris
1739

Vol 2, p. 37
Manhattan 1989
Manhattan Map Company
Viet Nam Memorial in Washington D.C.

Maya Ying Lin

58,000+ dead soldiers
Vol 2, p. 43

Names listed chronologically by death

Design Principles

• Use small multiples
  – Repeat visually similar graphical elements nearby rather than spreading far apart
Vol 1, p. 170

23 hours of LA air pollution

Vol 1, p. 173

Chromosomes of man, chimpanzee, gorilla & orangutan
Vol 1, p. 174

Consumer Reports

Vol 2, p. 68

NY Trains
Vol 2, p. 68

How to draw letters

Vol 2, p. 69

Calligraphy
More Recent Additions

<table>
<thead>
<tr>
<th>Sparklines: theory and practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Edward Tufte, May 22, 2004</td>
</tr>
</tbody>
</table>

**Sparklines**

Small, repeated graphics (frequently line graphs)

<table>
<thead>
<tr>
<th>Sparklines: Intense, Simple, Word-Sized Graphics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test: most common data display is a mean followed by some standard error. For example, a medical patient's current level of glucose is typically reported as a clinical record as a mean and standard error.</td>
</tr>
</tbody>
</table>

Sparkline Examples

<table>
<thead>
<tr>
<th>Fall 2012</th>
<th>CS 7450</th>
<th>67</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Fall 2012</th>
<th>CS 7450</th>
<th>68</th>
</tr>
</thead>
</table>
Design Principles

- Show mechanism, process, dynamics, and causality
  - Cause and effect are key
  - Make graphic exhibit causality

Space shuttle case we discussed first day

Vol 3, p. 144

Washington Post
Design Principles

- Escape flatland
  - Data is multivariate
  - Doesn’t necessarily mean 3D projection

Vol 2, p. 12

Guide for visitors to Ise Shrine, Japan
### Vol 2, p. 24

Timetable for Java railroad line

| Fall 2012 | CS 7450 | 73 |

### Vol 3, p. 90

Music history

| Fall 2012 | CS 7450 | 74 |

Steve Chapple and Reebee Garofalo
Design Principles

- Utilize layering and separation
  - $1+1 = 3$ or more
  - Good or bad
Design Principles

- Utilize narratives of space and time
  - Tell a story of position and chronology through visual elements
Vol 1, p.43 & Vol 2, p 110

Life of a beetle
L. Hugh Newman
Fall 2012    CS 7450

Vol 2, p. 102

Czech air schedule
Fall 2012    CS 7450
Design Principles

• Content is king
  – Quality, relevance and integrity of the content is fundamental
  – What’s the analysis task? Make the visual design reflect that
  – Integrate text, chart, graphic, map into a coherent narrative
Graph and Chart Tips

- Avoid separate legends and keys -- Just have that information in the graphic
- Make grids, labeling, etc., very faint so that they recede into background

Vol 2, p. 54

New Jersey Transit

Before

After
Using Color Effectively

• “The often scant benefits derived from coloring data indicate that even putting a good color in a good place is a complex matter. Indeed, so difficult and subtle that avoiding catastrophe becomes the first principle in bringing color to information: Above all, do no harm.”

Proper Color Use

• To label
• To measure
• To represent or imitate reality
• To enliven or decorate
Examples

• The bad...

Vol 1, p. 153
Description

“..despite its clever and multifunctioning data measure, formed by crossing two four-colored grids, this is a puzzle graphic. Deployed here, in a feat of technological virtuosity, are 16 shades of color spread on 3,056 counties, a monument to a sophisticated computer graphics system. But it is surely a graphic experienced verbally not visually. Over and over, the viewers must run little phrases through their minds, trying to maintain the right pattern of words to make sense of the visual montage: “Now let's see, purple represents counties where there are both high levels of male cardiovascular disease mortality and 11.6 to 56.0 percent of the households have more than 1.01 persons per room...”
“Color’s multidimensionality can also enliven and inform what users must face at computer terminals, although some color applied to display screens has made what should be a straight-forward tool into something that looks like a grim parody of a video game.”
Examples

- The good...

Vol 2, p. 91 & Vol 3, p. 76
Swiss Mountain Map

Guides for Enhancing Visual Quality

- Attractive displays of statistical info
  - have a properly chosen format and design
  - use words, numbers and drawing together
  - reflect a balance, a proportion, a sense of relevant scale
  - display an accessible complexity of detail
  - often have a narrative quality, a story to tell about the data
  - are drawn in a professional manner, with the technical details of production done with care
  - avoid content-free decoration, including chartjunk
Information Overload

What about confusing clutter? Information overload? Doesn’t data have to “boiled down” and “simplified”? These common questions miss the point, for the quantity of detail is an issue completely separate from the difficulty of reading. *Clutter and confusion are failures of design, not attributes of information.* Often the less complex and less subtle the line, the more ambiguous and less interesting is the reading. Stripping the detail out of data is a style based on personal preference and fashion, considerations utterly indifferent to substantive content. *Vol. 2, p. 51*

Minard graphic

<table>
<thead>
<tr>
<th>size of army</th>
<th>latitude</th>
<th>temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>direction</td>
<td>longitude</td>
<td>date</td>
</tr>
</tbody>
</table>

Fall 2012     CS 7450     99

Fall 2012     CS 7450     100
Graphical Displays Should

- Show the data
- Induce the viewer to think about substance rather than about methodology, graphic design, the technology of graphic production, or something else
- Avoid distorting what the data have to say
- Present many numbers in a small space
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a reasonably clear purpose: description, exploration, tabulation, or decoration
- Be closely integrated with statistical and verbal descriptions of a data set

Website & Seminar

The work of Edward Tufte and Graphics Press.

Topics covered in the one-day course include:
- Fundamentals of statistical design
- Evaluating evidence in visual presentations
- Statistical data displays, graphs, and maps
- Quantitative models, research, and financial presentations
- Consistency and credibility
- Effective presentations: in print and in person
- Information design
- Use of Powerpoint, videos, overheads, and handouts
- Scaling, layout, and notation
- Credibility of presentations
- Presentation and scientific visualizations
- Many practical examples

"One discovery day, the insights of this class led to new levels of understanding both for creators and viewers of visual displays."

"The essence of data visualization..."
Discussion Forum

At this moderated forum, I will answer questions dealing with information design. Others can then extend the discussion. I will try to answer questions that have general interest or where I have something to say. Not all questions will be answered, usually because I don't have the answer.

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Good gallery: http://simplecomplexity.net/nigel-holmes-gallery/

Interesting Contrast

Nigel Holmes

http://www.nigelholmes.com
HW 4

- Data analysis with Many Eyes
- Due next Monday

Upcoming

- Few’s Design Principles
  - Reading
    Few chapters 5-12

- InfoVis systems & toolkits
  - Reading
    Viegas et al, ‘07
Sources Used

E. Tufte, *The Visual Display of Quantitative Information*
E. Tufte, *Envisioning Information*
E. Tufte, *Visual Explanations*