Effective Visual Data Displays

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Abstract and Overview

Problem. Although much has been said on the topic of how to efficiently display data, examples of poorly constructed graphs, tables, and charts are still commonplace – even in academic books on how to analyze and present data to an audience with limited background in assessment, data, and/or statistics.

Overview. This poster synthesizes the thoughts, research, and main ideas of several authoritative writers, scientists, and professional organizations. The purpose is to provide a reference for individuals who may present data on a regular basis to stakeholders but who may not be well-read in the variety of skills, techniques, and research findings regarding best practices for data visualization.

> *The test of a graph's usefulness is its ability to communicate efficiently and effectively. If it* ***expresses the right information clearly and accurately in a way that speaks to your audience****, then it is effective. If not, regardless of how pretty it is, it's not only useless, it might even be harmful.*
>
> Few (2005a) p. 1

Generally, the ability to store information in our working memory is obviously limited. To account for this, data displays should be created in ways that make interpretation of the results relatively easy. This is not to say that graphs should not be complex; Tufte (2001) noted that we shouldn't underestimate the intelligence and ability of our audience members. Rather, tables and graphs should be constructed to minimize unnecessary effort needed to reach understanding.

The overarching purpose of visual displays should be to *show the data* – as opposed to simply incorporating fancy colors, showcasing novel computer graphics, or drawing attention to a poster or paper. Displays should also have a main message to convey, and should serve a clear purpose. E.g., tables and graphs serve different purposes, and these should be considered prior to creation and dissemination of data. The following recommendations can be used to more effectively communicate results and findings to an audience using visual displays.

Recommendations

Although there is some evidence that experts concerned with data visualization cite the same authorities, a variety of sources on the subject consistently suggest several best practices.

1. Show the Data. Above all else, remember that the data are the most important part of the message. Don't let them get lost in the display.

2. Identify Message. Figure out what exactly you are trying to convey. Sometimes a simple sentence can carry a message better than a table or a graph. Consider which type of method to present the data will best achieve your main goal(s). See 'Tables vs. Graphs' section.

3. Label Adequately. Several authorities on the subject agree that it is important for a visual display to stand on its own. Include information on the display so that it is understandable without consulting the surrounding narrative. E.g., title, data, axes, time period, source, and important points.

4. Avoid Unnecessary Additions. Excess gridlines, unnecessary color, lines, or decorations, can be distracting, so remove them completely. (See Recommendation #1!) Also, remember that many people are color blind. If color is necessary, use the website VisCheck to ensure your chart isn't difficult to read for those individuals.

5. Sort by the Data. Help your audience to better interpret the results by sorting the by the values observed. See the example below.

6. Avoid Pie Charts. Although this is a common recommendation, pie charts are frequently used. (See Microsoft Excel defaults.) The problem is that it is generally difficult for people to interpret area; better alternatives exist!

7. Label Data Directly. For line graphs and bar graphs, instead of relying on a legend which requires a lot of working memory effort, label the line or bar directly for ease of use. Put labels in the color of the line/bar.

8. Include Reference Points. When possible/appropriate, include reference points, criteria, or benchmarks to aid in quick interpretation of the results. E.g., include a line for a target score, the state average, or last year's average next to the institution's observed score(s).

9. Show Spread/Error. For more sophisticated research, use 95% confidence intervals (margin of error) around point estimates and focus on estimation and effect sizes over *p*-values.

Tables vs. Graphs

Use Tables When

- The display will be used to look up individual values.
- It will be used to compare individual values.
- Precise values are required.
- The quantitative values include more than one unit of measure.
- Both detail and summary values are included

Use Graphs When

- The message is contained in the shape of the values (e.g., patterns, trends, and exceptions).
- The display will be used to reveal relationships among whole sets of values.

Few (2012) p. 51

Additional Resources

Many individuals and groups (including many professionals not mentioned here) are doing great work with data visualization or can be referred to as resources for ideas, techniques, and inspiration when creating visual data displays.

For example, see: fivethirtyeight, Perceptual Edge, Data Hero, The University of Reading, Vanderbilt University, OpenIntro Statistics, For those interested, the R Statistical Programming Language allows for free, customizable data analysis and data presentation using a variety of existing packages created by professionals in the field.

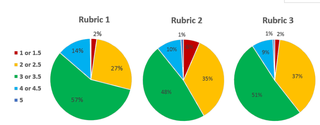
Takeaway Points

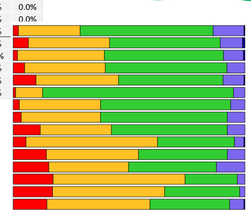
Recommendations	*Reference(s)*
✓ Show the data above all else – multivariate format is a plus	3,5,6,7,11
✓ Identify your purpose, main question, message, and or goal	5,6,7,11
✓ Label data, axes, important events, and cite sources	2,5,6,7,8,9,11
✓ Avoid unnecessary additions – e.g. excess gridlines, color	5,6,7,9,10,11
✓ Sort/organize categories by the data	5,6,7
✓ Avoid pie charts*	4,5,6,11
✓ Avoid legends – label data directly, when possible	5,6,9,11
✓ Include criteria and/or benchmarks in charts for comparison	3,5,6
✓ Show spread, distribution, and/or margin of error	1,2,3

** Nicol & Pexman (2010) state that pie charts are not often used in psychology, but they do actually offer guidelines for their inclusion in manuscripts and reports.*

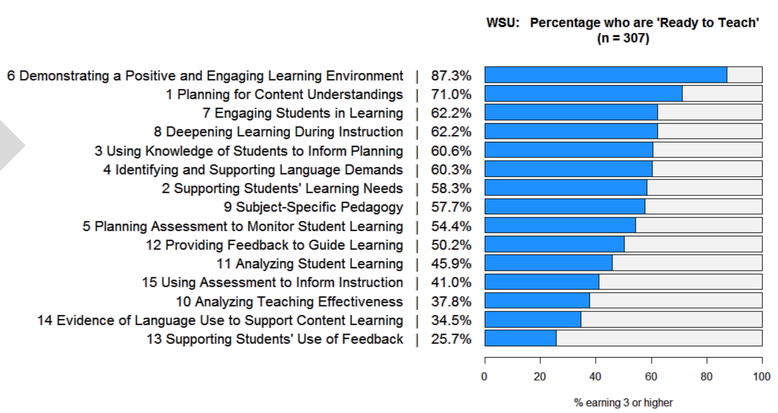
Examples

Test Performance	*1 or 1.5*	*2 or 2.5*	*3 or 3.5*	*4 or 4.5*	*5*
Rubric 1	2.3%	26.7%	57.3%	13.4%	0.3%
Rubric 2	6.5%	35.2%	47.6%	9.8%	1.0%
Rubric 3	2.0%	37.5%	51.5%	8.5%	0.7%
Rubric 4	4.9%	34.9%	52.4%	7.8%	0.0%
Rubric 5	9.8%	35.8%	45.0%	9.1%	0.3%
Rubric 6	1.0%	11.7%	82.4%	4.9%	0.0%
Rubric 7	2.6%	35.2%	56.0%	6.2%	0.0%
Rubric 8	3.6%	34.2%	54.7%	7.5%	0.0%
Rubric 9	11.7%	30.6%	50.2%	7.5%	0.0%
Rubric 10	5.5%	56.7%	33.2%	4.2%	
Rubric 11	14.3%	39.7%	38.4%	7.5%	
Rubric 12	15.3%	34.5%	37.8%	12.4%	
Rubric 13	17.3%	57.0%	22.5%	3.3%	
Rubric 14	16.9%	48.5%	32.2%	2.3%	
Rubric 15	14.7%	44.3%	34.5%	6.2%	





> *The only worse design than a pie chart is several of them.*
>
> Tufte (2001) p. 178



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