

One Tenth of A Picture Is Worth A Hundred Words

Partially-Graphic Ways of Conveying Information

Donald Byrd

Woodrow Wilson Indiana Teaching Fellow
Indiana University Bloomington

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There's much truth to the old saw, "a picture is worth a thousand words". It applies to teaching the STEM disciplines as much as anything, and I think most STEM teachers are reasonably aware of it. But there's a discipline called *graphic communication* that covers far more than that one idea, and STEM teachers seem much less aware of the rest of it. Many principles of graphic communication apply even when there's nothing like a picture in the normal sense, and that's what I mean by "one-tenth of a picture": using graphic elements in text, formulas, etc. Here are a few examples and guidelines from my own experience: some from classroom use, some from other situations. For a great deal more on how to use graphical elements of many kinds to convey information, see Edward Tufte's well-known books (Tufte, 1990, 1997, 2001). (However, to my knowledge, the "tenth of a picture" phrase is my own.)

1. Showing Grouping

Show grouping explicitly. As a student teacher, to help my 6th-graders remember the order of operations in evaluating complex expressions, I taught the mnemonic "**PEMDAS**" (or "Please Excuse My Dear Aunt Sally"), just as my mentor did: first handle all Parentheses, working left to right; then all Exponents, Multiplication, Division, Addition, and Subtraction, in that order, working left to right in each case. But, of course, that's wrong! Every teacher explains to their students that, actually, multiplication and division are "on the same level", and likewise addition and subtraction:

$$3 * 6 / 4 * 2 = (18 / 4) * 2, \text{ not } 18 / (4 * 2)$$

$$10 - 3 + 2 = (10 - 3) + 2, \text{ not } 10 - (3 + 2)$$

As a student teacher, at first I taught my 6th-graders to think of "PEMDAS", just as my mentor did. But I was not surprised to find many of them trying to do all multiplication before any division, and all addition before any subtraction. Then it occurred to me to have them use "**PE(MD)(AS)**" instead; the parentheses helped quite a bit. A vertical arrangement also helped:

P
E
MD
AS

This is slightly more graphic than "PE(MD)(AS)", and it eliminates the need for the parentheses.

2. Presentation of Numbers: Needless Digits, Words, Etc.

A variation of Strunk and White's (2000) famous admonition to writers of prose, "Omit needless words", applies to numbers. Tufte (1990, pp. 93–105) discusses the concepts of *data-ink* and a *data-ink ratio*, i.e., the proportion of ink that conveys data values to the total ink on the page, including axes, labels, grid lines, etc. He argues the data-ink ratio should be as high as possible, within reason: that is, relatively little of the ink on the page should be devoted to stuff that could be erased without losing data. This is an important idea, and all of the following guidelines have to do with it. These rules are particularly important for lists and tables of numbers, but they apply to individual numbers as well.

Don't obscure numeric values with leading zeros. In many situations, the highest and lowest values in a list or table will jump out at the reader—that is, unless you hide them by including leading zeros. Paying for parking at the Indianapolis International Airport, I observed the machine's display showing:

```
AMOUNT DUE
$ 00006.00
```

The four leading zeros make it considerably harder to see the nonzero unit's digit. That's not a big deal with only one number, but in a table, it would be.

Be careful writing numbers out in words. Here's an excerpt from a newspaper article on the so-called "Obamacare" health care reform law, referring to a poll: "Forty-one percent said they expect it to be fully implemented with minor changes, while 31 percent said they expect to see it take effect with major changes. Only 11 percent said they think it will be implemented as passed." Saying "41 percent" instead of "forty-one percent" would have made it easier to compare the three numbers given, as well as to see the interesting fact that the total percent (83) falls well short of 100! On the other hand, writing, say, "There are 3 reasons to use this method" instead of "There are three reasons to use this method" just looks silly. A common and sensible rule is to use the word form only for whole numbers of one digit; but even then, it should be used sparingly, and not when you want the reader to compare one-digit numbers to multiple-digit numbers.

Use scientific notation thoughtfully. In particular, don't switch back and forth between standard and scientific notation needlessly; and...

Use an appropriate number of significant figures. The usual problem here is obscuring important information by showing far more digits than necessary. This is a common mistake, and one reason is undoubtedly that many computer programs and programming languages give numeric values to maximum precision by default.

Here's some of the output from a Java program of mine that computed pi to 5 decimal places. I specified the precision of the approximation to pi, but used default precision for the error. I also let the Java system choose between standard and scientific notation.

```
pi = 3.1405926 (error=-9.9999749998981E-4)
prevPi = 3.1425936 (error=0.001001000750251002)
(pi+prevPi)/2 = 3.1415931 (error=5.005001257885056E-7)
```

I think you'll agree that giving the error values in the following way makes them far more readable:

```
pi = 3.1405926 (error=-0.001000)
prevPi = 3.1425936 (error=0.001001)
(pi+prevPi)/2 = 3.1415931 (error=0.0000005)
```

But why did I accept the inferior first versions? Because it was much easier than figuring out how to do things “right”: a lousy excuse, but a common fact of life!

3. Lists and Tables of Anything: Typography

Use any eye-catching typographic distinction—boldface, italic, color, size, etc.—to emphasize extreme or otherwise interesting values. This obviously applies to tables where the cells contain numbers, but “interesting” values can appear in any kind of data. Here’s an example, from a class gradebook of mine. Low scores are in *red bold italics*. High scores are in *green bold italics, underlined*. I added underlining to them because green isn’t that eye-catching.

<i>Exam 3 (of 25)</i>	<i>Exam 3 CPTs</i>	<i>Exam 4 (of 30)</i>	<i>Exam 4 CPTs</i>	<i>Exams 1-4 total, low score repl.</i>	<i>FINAL EXAM (of 50)</i>	<i>FINAL EXAM CPTs</i>	<i>EXAM CPTs (of 560)</i>
18	72.0	25	83.3	287.9	31.0	99.2	387
<i>24</i>	96.0	29	96.7	358.3	34.0	108.8	467
<i>25</i>	<i>100.0</i>	<i>30</i>	<i>100.0</i>	389.3	46.0	147.2	<i>537</i>
<i>11</i>	<i>44.0</i>	18	60.0	191	<i>0.0</i>	<i>0.0</i>	<i>191</i>
<i>0</i>	<i>0.0</i>	<i>12</i>	<i>40.0</i>	112.1	<i>0.0</i>	<i>0.0</i>	<i>112</i>
23	92.0	21	70.0	298.3	<i>26.0</i>	<i>83.2</i>	382
17	68.0	<i>0</i>	<i>0.0</i>	111.2	<i>0.0</i>	<i>0.0</i>	<i>111</i>
16.5	66.0	23	76.7	258.9	<i>26.0</i>	<i>83.2</i>	342
18	72.0	18.5	61.7	286.2	<i>27.0</i>	<i>86.4</i>	373
21	84.0	22	73.3	317.5	<i>22.0</i>	<i>70.4</i>	388
20	80.0	<i>30</i>	<i>100.0</i>	371.9	41.0	131.2	503
15	60.0	21	70.0	231.4	<i>22.0</i>	<i>70.4</i>	<i>302</i>
<i>25</i>	<i>100.0</i>	<i>30</i>	<i>100.0</i>	388.2	45.0	144.0	<i>532</i>
21	84.0	22	73.3	307.1	33.0	105.6	413
22	88.0	18	60.0	321.3	33.0	105.6	427
21	84.0	28	93.3	336.3	41.0	131.2	468
21	84.0	28	93.3	345.6	36.0	115.2	461
17.5	70.0	23	76.7	297.2	<i>23.0</i>	<i>73.6</i>	371
21	84.0	<i>30</i>	<i>100.0</i>	336.9	42.0	134.4	471
22	88.0	28	93.3	310.3	<i>28.0</i>	<i>89.6</i>	400
<i>25</i>	<i>100.0</i>	<i>30</i>	<i>100.0</i>	397.3	<i>48.0</i>	<i>153.6</i>	<i>551</i>
22.5	90.0	25	83.3	306.3	35.0	112.0	418
15	60.0	20	66.7	224.5	<i>21.0</i>	<i>67.2</i>	<i>292</i>

4. Lists and Tables of Anything: An Alternative to Typography

Sometimes typographic distinctions aren’t practical or would be difficult to make, for example, in unformatted text (as in a .txt file or some email, etc.). In such cases, you can often add simple graphics with text characters. Here’s an example. The numbers are an imaginary type-1 diabetic’s blood A1C levels, which are typically checked every few months; a value of 7 or less is generally considered very good, one of over 9 not good at all.

Key: * = over 7, ** = over 8, *** = over 9

2007	April	9.1	***
	June	7.5	*
	Sept.	7.8	*
	Dec.	9.1	***
2008	March	7.8	*
	June	8.3	**
	Sept.	7.1	*
	Dec.	7.5	*
2009	Mar.	6.8	
	June	7.4	*
	Aug.	7.3	*
2010	Dec.	7.1	*
	June	7.3	*
	Sept.	7.7	*
2011	Dec.	7.5	*
	Mar.	7.8	*
	June	8.4	**
2012	Aug.	7.6	**
	Dec.	8.7	**
	Mar.	7.5	*
	Jul.	8.5	**

References

- Strunk Jr., William, & White, E. B. (2000). *The Elements of Style*, 4th ed. New York: Longman.
- Tufte, Edward (1990). *Envisioning Information*. Cheshire, Connecticut: Graphics Press. See comments on his *The Visual Display of Quantitative Information*.
- Tufte, Edward (1997). *Visual Explanations: Images and Quantities, Evidence and Narrative*. Cheshire, Connecticut: Graphics Press. See comments on his *The Visual Display of Quantitative Information*.
- Tufte, Edward (2001). *The Visual Display of Quantitative Information*, 2nd ed. Cheshire, Connecticut: Graphics Press.

