Imagine you’re visually impaired and you rely on a screen reader to read text aloud and interpret images for you on your computer. Would you be able to make sense of scientific charts and graphs? Or get information about what they look like and the information they convey?

For many students in this position, the answer has been “no”, or only in ways that are limited and far from ideal. Charts, graphs, and maps use visuals to convey complex data to users. But since they are images, these visuals can present serious accessibility issues for colorblind or low-vision viewers and users of screen readers.
The single, most common mistake when creating a chart or graph is the overabundance of data. In the social sciences, one multi-faceted survey question looking at age, gender, and educational status could be rich enough to lend itself to three or four graphs. Visuals should have an overarching takeaway message that isn’t bogged down by too many comparisons.

This excerpt from The Matrix of Race, by Rodney Coates, Abby Ferber, and David Brunsma is a good example of a figure that has been simplified by a reorganization of data to streamline and get to the core of the discussion.

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### Original Request

**Figure 1.17 Frequency of Physical Assault Based on Sexual Orientation, Gender Expression, and Gender Experienced by LGBTQ Students in the Past School Year**

- Sexual Orientation
  - Frequently: 1.6%
  - Often: 1.2%
  - Sometimes: 3.3%
  - Rarely: 6.3%

- Gender Expression
  - Frequently: 1.6%
  - Often: 1.3%
  - Sometimes: 2.9%
  - Rarely: 5.4%

- Gender
  - Frequently: 1.3%
  - Often: 1.0%
  - Sometimes: 2.7%
  - Rarely: 5.0%

---

**Figure 1.18 Frequency of Other Identity-Based Bullying or Harassment Experienced by LGBTQ Students in the Past School Year**

- Race/Ethnicity
  - Frequently: 1.9%
  - Often: 2.9%
  - Sometimes: 7.7%
  - Rarely: 13.1%

- Disability
  - Frequently: 2.1%
  - Often: 3.2%
  - Sometimes: 8.5%
  - Rarely: 11.8%

- Religion
  - Frequently: 2.1%
  - Often: 3.1%
  - Sometimes: 8.0%
  - Rarely: 13.9%

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### Final Figure

**FIGURE 6.4 Harassment, Bullying, and Physical Assault Experienced by LGBTQ Students**

- **Sexual Orientation**
  - Sometimes or rarely: 2.8%
  - Frequently or often: 9.6%

- **Gender Expression**
  - Sometimes or rarely: 2.9%
  - Frequently or often: 8.3%

- **Gender**
  - Sometimes or rarely: 2.3%
  - Frequently or often: 7.7%

- **Race/Ethnicity**
  - Sometimes or rarely: 4.8%
  - Frequently or often: 20.8%

- **Disability**
  - Sometimes or rarely: 5.3%
  - Frequently or often: 20.3%

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*Source: Kosciw, Greytak, Zongrone, Clark, and Truong. The 2017 National"
In-Text Summaries and Placement

Generally speaking, alt-text and long descriptions cannot do justice to a complex visual. One way to describe a chart is to contextualize the chart in the narrative of your book, so that a student who is reading through the narrative can learn about the data as they work through the material. It is important to explain what the figure depicts and why it matters in order for context and relevance to be conveyed.

It is a best practice to place the figure in the text after it is first mentioned in the narrative. For books with a large number of visual elements, it is best to work with the Editorial team to ensure there is a good balance between the narrative and the art program.

Within Surrounding Narrative

Person-first language places the individual first instead of their characteristics, disability, condition, or circumstance. The goal of person-first language is to acknowledge the equal value of every individual, before attaching descriptions or identities to that person. It is recommended by many organizations and style guides, which you can find at the end of the document.

In contrast, identity-first language places the characteristic first and can perpetuate the idea that someone’s condition or circumstance define who they are.

[h2] Sexual Minorities

In 1999, the Gay, Lesbian, and Straight Education Network (now known simply as GLSEN) began conducting the National School Climate Survey. This important survey, conducted every 2 years, seeks to measure students’ experiences within their schools. In the most recent data collection, from the 2016–17 school year, a sample of 23,001 students across all 50 states and more than 3,000 school districts was canvassed (Kosciw, Greytak, Zongrone, Clark, and Truong 2018). The results of the survey, since 1999, have consistently revealed a previously concealed story: LGBTQ students experience hostile school climates, absenteeism, lower educational aspirations and achievements, and poor psychological well-being. Respondents have reported verbal assaults on their sexuality, gender, and gender expression (while transgender is not about sexual orientation or sexuality, the data reported include these students along with LGBT youth)(see Figures 6.4a and 6.4b). Physical assaults have been reported as well, and reports of intervention by fellow students have been rare. Such incidents are reported to school authorities only about 42% of the time, and to family members only about 43% of the time.

[[Insert Figure 6.4]]

The report on the National School Climate Survey for the 2016–17 school year shows that while all LGBT students experience verbal and physical harassment in their schools, LGBT students of color experience such harassment in addition to the daily microaggressions that they receive when others make assumptions about their other statuses (such as race and class; Kosciw et al. 2016). The report, and LGBTQ students themselves, offer several solutions to these problems:

- Increased opportunities for gay-straight alliances been shown to have significant positive impacts on school cultures and climates.
- Curricula must be inclusive of the experiences of LGBTQ individuals, histories, and voices.
- Supportive teachers and administrators are essential.
- Comprehensive antibullying and antiharassment policies and laws should be in place.
In-Text Summaries

This excerpt from Culture Counts, Fifth Edition, by Serena Nanda and Richard Warms, is a good example of an author presenting data in tables and then comparing those tables to contextualizing the data in the narrative.

**<H2>Income Inequality in the United States</H2>**

The common notion that almost everyone in the United States is middle class tends to camouflage the relatively high levels of income inequality in the nation. One conventional way of analyzing income is to divide all U.S. households into quintiles (ranked groups of 20 percent) and ask what income levels and percentages of income are held by different fifths of the households. *Table 8.1* presents this information for the United States in 2019.

**Table 8.1 Household Income by Quintiles, 2019**

<table>
<thead>
<tr>
<th></th>
<th>Average Household Income in Each Quintile</th>
<th>Upper Limits of Quintile</th>
<th>Percentage Share of Total U.S. Income¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorest Quintile</td>
<td>$15,286</td>
<td>$28,084</td>
<td>3.1</td>
</tr>
<tr>
<td>Second Quintile</td>
<td>$40,652</td>
<td>$53,503</td>
<td>8.3</td>
</tr>
<tr>
<td>Third Quintile</td>
<td>$68,938</td>
<td>$86,488</td>
<td>14.1</td>
</tr>
<tr>
<td>Fourth Quintile</td>
<td>$111,112</td>
<td>$142,501</td>
<td>22.7</td>
</tr>
<tr>
<td>Wealthiest Quintile</td>
<td>$254,449</td>
<td>Unlimited</td>
<td>51.9</td>
</tr>
<tr>
<td>Wealthiest 5% of American households²</td>
<td>$451,122 (lower limit of top 5%)</td>
<td>$270,002</td>
<td>23</td>
</tr>
</tbody>
</table>

Notes:

1. An example of how to read numbers in this column: Households in the poorest 20 percent of the U.S. population, taken all together, received 3.1 percent of the total of all the income earned in the United States in 2019.

2. This group is also included in the wealthiest 20 percent of households.

The chart shows the degree of household income inequality in the United States as reported by the U.S. Census Bureau. Several indicators stand out. The average family in the top quintile makes $254,448, more than the combined average income of families in the first four quintiles ($15,286 + $40,652 + $68,938 + $111,112 = $235,988). The share of the national income made by the first through fourth quintiles, at 48.2 percent, is substantially less than the 51.9 percent share of income made by the wealthiest 20 percent. The wealthiest 5 percent of the nation take home 23 percent of the national paycheck, while the poorest 40 percent take home less than 12 percent.

However, this chart substantially understates the degree of economic inequality in the United States. This is because real wealth is not equal to income but rather is income plus assets. And the distribution of assets in the United States greatly favors the nation’s wealthiest families. The economist Edward N. Wolff has been tracking wealth trends in the United States over the past two decades. Table 8.2 shows Wolff’s analysis of the distribution of wealth (as opposed to income) in the United States in 2016.

Table 8.2 Wealth Inequality in the United States, 2016

<table>
<thead>
<tr>
<th>Percentage Share of Wealth Held By</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Weakest 1%</td>
<td>39.6</td>
</tr>
<tr>
<td>Next 4%</td>
<td>27.1</td>
</tr>
<tr>
<td>Next 5%</td>
<td>12.1</td>
</tr>
<tr>
<td>Next 10%</td>
<td>11.1</td>
</tr>
<tr>
<td>Highest Quintile Combined</td>
<td>89.9</td>
</tr>
<tr>
<td>Fourth Quintile</td>
<td>8.2</td>
</tr>
<tr>
<td>Third Quintile</td>
<td>2.4</td>
</tr>
<tr>
<td>Poorest 40%</td>
<td>-0.5</td>
</tr>
</tbody>
</table>


These tables show a high degree of wealth inequality in the United States. The wealthiest 20 percent of U.S. households control the overwhelming majority of wealth. However, even within this group, there is great inequity. The top 5 percent of households control far more wealth than the rest of the nation combined. On the other side of the wealth spectrum, we see that official statistics probably underestimate the amount of poverty in the United States. Officially, 11.8 percent of Americans lived in poverty in 2016 (Semega et al. 2019). However, the tables show us that 20 percent of households have incomes of less than $25,600. Because the poverty threshold for a single person living alone was $12,784 in 2018, many of these households are not officially poor. But, you are not doing very well at this income
level, no matter how few people are in your family. Further, according to Wolff (2017, 46), the average net worth of the poorest 40 percent of U.S. households is negative. This means that these households currently owe more money than the total of their assets. If they were to sell everything they owned and use it to pay their debts, they would still owe money. There is no money available for emergencies or financial shocks such as medical expenses, car repair, or the loss of a job. Many households in this category have members with steady incomes, people who consider themselves middle class. However, it is very easy for them to fall into poverty. Together, the tables show that the United States is probably best characterized as a middle-class and poor nation with a small and extraordinarily wealthy upper class.

Supplement Color-Coding of Charts

Differences in texture, line style, and different shades of color can improve accessibility for colorblind users. We cannot rely solely upon colors to mark differentiations on figures and maps.

If a 4-color figure is going into a 2-color or 1-color book, or if a user of a 4-color book cannot see colors, the figure might end up without clear visual differentiation, like this:

Best practice is to use a contrast checker such as the free Colour Contrast Analyser (https://www.tpgi.com/color-contrast-checker/) to evaluate the contrast ratio and confirm that your content passes the standards for WCAG 2.0 (https://www.w3.org/TR/UNDERSTANDING-WCAG20/visual-audio-contrast-contrast.html), Level AA or higher.

Please be explicit in the typesetter callouts if we need the typesetter to apply patterns to any art. Please work with your Editorial team to provide appropriate direction to the typesetter with the artwork you supply.

- Color contrast ratios (for background vs. foreground/text) must meet or exceed 4.5:1.
- Monochromatic color schemes are most helpful to colorblind users because, even if the colors themselves do not appear the same way as they would to someone who has no visual impairments, there will be variations in the shade that they can distinguish.
• When using a monochromatic color scheme, there needs to be sufficient contrast between the different shades so that it is possible for all users to be able to easily distinguish between them.

  o Ideally, there should be about a 20% difference between shades of a single color on 1-color interiors, which will give you 5 base shades (6 if you have strokes around your graphs and white is included) to work with before you need to start adding patterns into the mix. This is due to a printing effect called dot gain, which is where the ink spreads when it is being absorbed into the paper, meaning that all the colors in print will look slightly darker than they do on screen.

• That said, oftentimes we will need to go beyond just shading—nuanced differences in colors can be difficult for many people to perceive. Utilizing different patterns/textures instead of/in addition to shading will help all users, as will redundantly coded figures.

• Redundantly coded figures apply both color and shapes to show differences. This can include various dotted, hatched, shaped, or lettered/numbered codes.

  o This graph shows patterned lines and symbols, making it easier to distinguish color. Lines have different shapes, and different symbols are used:

• Best practice would be to apply textures/patterns in addition to colors in all cases. Any categories without a texture/pattern applied should utilize colors that are apparently different from each other.

  o This graph shows both colors and hatching. Each object is distinguishable even without color vision:
These bar charts with solid sections of red, blue, and green may not be distinguishable for colorblind users. The key to the chart only refers to colors, which is difficult to interpret if the chart is converted to grayscale.

Spacing on bar charts can be an issue, as well. This example has gaps between each bar, but if the bars are touching, then they need to have a stroke/border around them even with individual colors so that the 3 bars can be clearly distinguished from one another.
Accessible Bar Chart

The colors in the chart have been converted to a gradient of blue. Colorblind users can use the different levels of darkness to tell the bars apart. The labels for each category, as well as the numerical data points, have been added to the bottom of the chart, so that viewers do not have to only rely on the key to interpret the data. This information could be provided within the alt text or long description of the chart, as well.

A best practice is for the surrounding text to include the actual number for each data point above/below/on the graph. That can also help for a reader with accessibility concerns to understand the content.

Another way to make bar charts more accessible is to use patterns and textures in design to help further differentiate the bars.

![Accessible Bar Chart](image)
For line charts, changing the style of the graph lines and adding labels increases usability.

**Inaccessible Line Chart**

This chart uses three colors of lines, all of similar brightness, with a key that only refers to color. In grayscale, these colors are virtually identical. Additionally, the red and green shades selected would look identical to an individual with red-green colorblindness (deuteranopia or protanopia).
Accessible Line Chart

The colors in the original figure have been adjusted to provide adequate contrast. There are now distinct light, medium, and dark colors.

The figure now incorporates both adequate color contrast and different line styles. Although the color contrast alone is adequate to make the figure accessible, the distinct line styles add to its accessibility.

One final way to improve accessibility is to place the data categories next to the lines instead of in a legend. Labels are helpful for people with cognitive disabilities and those with low vision who may want to zoom in on a graphic or might have difficulty associating the legend labels with the lines. Labels can also be used in conjunction with a legend depending on available space.
Maps

All maps need to include a **sufficiently descriptive title** to help provide context and meaning. They must also include a **legend/key** to identify the meanings of the different colors/patterns used. Additional context may need to be added to the legend.

Maps are designed/ rendered and subsequently interpreted (read) in layers. The topical thematic information should be prominent, and the background cartography should be subtle and less prominent. The intent is to have a strong color-contrast ratio generally between overlaying thematics (labels, lines, symbols, etc.) and the underlying land, keeping in mind that some of the land colors are topical and thematic in nature as well. An accessible design uses design techniques that would be obvious to users who are colorblind, but not too obtrusive for a reader who is not colorblind. Therefore, it is often best practice to apply some subtle textural elements (i.e., patterns) to help further distinguish between thematic categories.

Providing **text-based tags** may be appropriate in some instances to help identify smaller locations or distinguish them as important. However, it is essential that the text be of a legible size and not add additional clutter to the map, rendering it more difficult to read. **Alt-text and long descriptions** should be provided to describe the layout of the map, its purpose, and findings.
**Pie charts**

Pie charts should have a solid color stroke (ideally black) and/or a gap/white stroke between each section of a pie chart so that the individual sections can be clearly delineated, even with low contrast on colors.

Avoid any 3D effects on the pie because this will visually distort the proportions of the sections, making them appear inaccurate.

**Labels and Text**

We are moving toward some standardization over labeling in graphs across all our books. It is a best practice to deemphasize the axis labels, similar to how news stations handle these graphics—gray font and hairline rules for graph grids. This is so that visual guides are present but there is more focus on the graph itself (see sample graph below from NPR, but note that the colors are not fully colorblind safe).
Font sizing and leading

For data-driven graphics, labels should make use of ADA compliant fonts whenever possible, ideally sans-serif fonts. Work with your Editorial team to provide appropriate typesetter guidelines.

Data Sources and Analysis

Comparisons

Making comparisons between subgroups is a common strategy for analyzing and presenting data. When looking at patterns, it is natural for researchers to wonder “Is this normal? Is that too low? Is that too high?” Sometimes the way this strategy is implemented implicitly positions certain groups as normative. When evaluating the comparisons to include in a book, keep the following tips in mind:

• If comparisons are necessary for your audience, think carefully about the comparison or reference groups the research is using. Using a majority group as a reference for comparison (white, straight, cisgender, etc.) implies that these groups are the standard against which all others should be measured.