

# Using Basic Data Visualization Methods to Explore LibQual+® Data

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Well-designed graphs impart information about quantitative data that usually cannot be gained in any other way. Graphs reveal patterns, trends, and exceptional values and enable quick and repeated comparisons of ample amounts of data. And, as Stephen Few (2009, p. 6) reminds us, they do more:

[Graphs] extend the capacity of our memory, making available in front of our eyes what we couldn't otherwise hold all at once in our minds. In simple terms, information visualization helps us think.

Visualization facilitates both exploration and understanding of data. Accordingly, LibQual+® survey findings include graphs of both survey responses and attributes of survey respondents. Responses to the twenty-two core survey items are illustrated in the LibQual+® hallmark graphic, the radar chart.

## Interpreting LibQual+® Radar Charts

Essentially, LibQual+® radar charts are self-contained maps of respondent groups' standings on the three survey dimensions. For a given group, the charts describe service quality as mean values for individual dimension items, as well as magnitudes and distributions of superiority gaps and adequacy gaps for the items. The Association for Research Libraries (ARL) standard notebooks advise libraries to look for "symmetry or uniformity of data" by examining the shape, location, thickness, and color of concentric areas delineated by the measures and their gaps. Positive versus negative adequacy and superiority gaps are encoded using the familiar yellow/blue/red/green color scheme. Relative sizes and shapes of chart regions paint a single picture of service quality for the institution.

The main advantage of a radar chart is this distillation of a large amount of information into a single visual representation. Its summative nature permits direct comparisons of service quality patterns among survey respondent groups, within or among institutions, and between survey

years. At the same time, libraries can “drill down” to examine details by visually unpacking the components of the charts, keeping in mind their basic structure (see figure 2).<sup>1</sup>

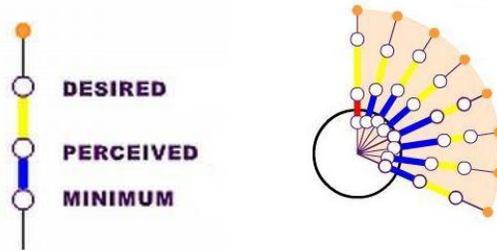


Figure 1. LibQual+<sup>®</sup> Service Quality Levels Plotted on Radiating Spokes

Source: Learn About LibQual+<sup>®</sup> Presentation, [http://www.libqual.org/about/about\\_survey/tools](http://www.libqual.org/about/about_survey/tools)

Sometimes this process can be difficult due to visual distractions of coloring, varied line angles, and the lack of stationary baselines from spoke to spoke. For this reason this paper proposes a set of simple graphical formats to assist with detailed exploration of LibQual+<sup>®</sup> data.

Before considering alternate graphical formats, it will be helpful to revisit the construction of standard radar charts. In the charts, survey mean values are plotted on spokes to form segments which are directly analogous to *stacked bars* (see figure 2). Users gauge relative quantities by comparing one segment (bar) in a single spoke with its matching segment, and segments from different spokes with each other.

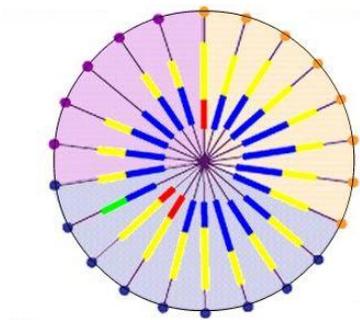


Figure 2. Color-coded Segments on Spokes Indicate Adequacy and Superiority Gaps

Unfortunately, stacked bars (sometimes called *divided bars*) are not ideal for visually estimating lengths of laterally aligned segments (Cleveland, 1994, pp. 265-266). Visual comparisons of

<sup>1</sup> In the radar charts, shapes of color-coded areas are determined both by the data and the order in which items are arranged around the radial. Since this order is deliberate but arbitrary, the geometric shape of a dimension’s color-coded area is not as meaningful as its overall spread and thickness.

lengths are more accurate when bar segments are separate and located parallel to each other on a common baseline, as they are in the format of traditional bar charts. Thus, perceptual difficulties inherent to radar charts make bar charts useful supplements to the former for the purpose of comparing data visually.

### Using Bar Charts to Explore Patterns in Libqual+® Mean Service Quality Measures

Bar charts presented here were rendered using Tableau Software due to its ease of use and advanced features.<sup>2</sup> One attractive feature of this software is its interactive graphical capabilities. Appropriately deployed interactive features can increase the information content of traditional charts. Figures 3A through 3C show two interactive features available in Tableau Software, and in other available statistical software.

Figure 3A depicts service quality levels for surveyed faculty among the nine items in the affect of service dimension. The legend at the right indicates that Min(imum) levels are coded brown, Per(ceived), green, and Des(ired), gold. Using the same chart as in figure 3A, figure 3B shows the software's behavior when the cursor hovers over the Per(ceived) bar in the item AS-8 columns. Notice the bubble indicating the mean score to be 7.97. This interactive feature keeps charts uncluttered while making details available on demand. (Using this feature makes bar value labels and horizontal gridlines unnecessary in these charts.)

Figure 3C contains two additional renditions of the chart in figure 3A. When a user clicks on a measure in the legend, bars for that measure are highlighted. In the upper chart in figure 3C the Min (brown) measure has been selected, causing the remaining two—Per(ceived) and Des(ired)—to be grayed out. In the lower chart in figure 3C shows the Per (green) legend item has been selected.

To demonstrate how effectively bar charts can reveal data patterns, it will be useful to begin with a comparison of two survey respondent groups. Figure 4 depicts service quality levels for one dimension, affect of service, for all respondents and for the faculty respondent group. In each item column, a dotted line across the bars marks the height of the Min (brown) bar. Within each column these lines assist in viewing the extent to which perceived and desired levels exceed minimum levels.<sup>3</sup>

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<sup>2</sup> Charts presented in this paper were created using the public version of Tableau Software. See [www.tableausoftware.com/public/](http://www.tableausoftware.com/public/).

<sup>3</sup> Typically, bar charts should include zero in their horizontal or vertical axes (depending on the chart's orientation) to assure that relative visual comparisons will be reliable. To conserve space zeros have been omitted from the chart axes in figures 3A – 3C, 4, 6, and 7, making comparisons

In figure 4, in the upper chart notice for items AS-4 through AS-9 that Min, Per, and Des levels are quite similar for this group of all respondents—measuring roughly 6.6, 7.3, and 8.0 respectively. Levels for AS-1 and AS-2 are substantially lower, especially the minimum values. Measures for item AS-3 are all slightly higher than the rest of the items, at 6.9, 7.7, and 8.2.

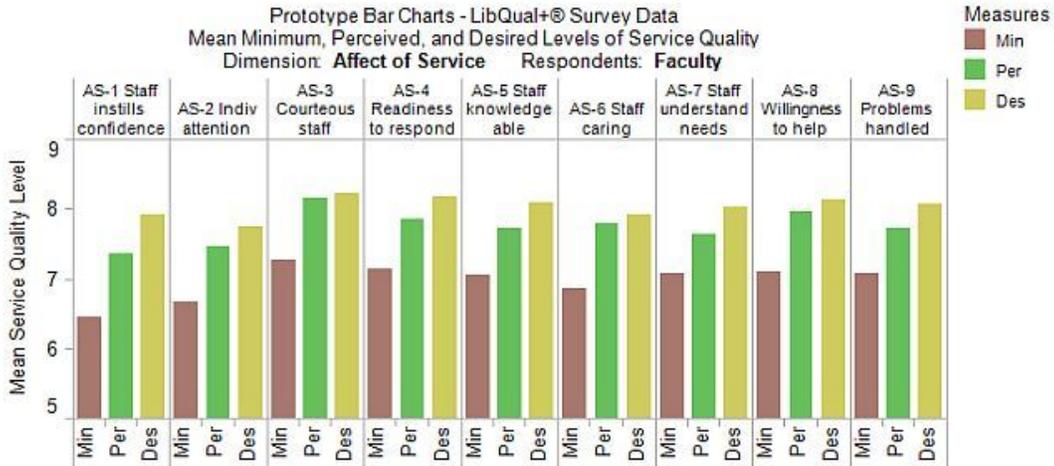


Figure 3A. Bar Chart for Affect of Service Mean Service Quality Levels for Faculty

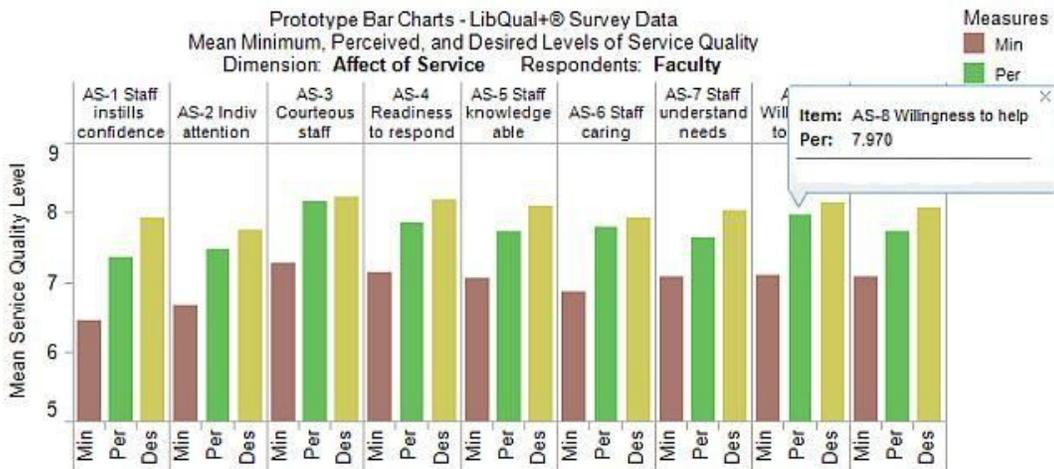


Figure 3B. Tableau Software Interactive Feature: Data Value Lookup

of total bar lengths inappropriate. Readers should compare only *differences in bar lengths* in these figures using the charts' vertical axes and horizontal dotted lines as guidelines.

As seen in the lower chart in figure 4, mean measures for faculty respondents are more uniform than for all respondents. Levels for AS-5 through AS-9 are fairly similar, although perceived levels for AS-6 and AS-8 are quite close to desired levels. And for AS-3 the superiority gap is especially small (0.7). From patterns observable in figure 4, we can conclude:

*For most of the items, faculty report about the same levels of desired service quality as do the group of all respondents. The faculty's mean minimum expectations are slightly (about 0.3) higher than all respondents, especially for the first two items in the affect dimension. Faculty report consistently (about 0.4) higher mean levels of perceived service quality on all items compared to all respondents.*

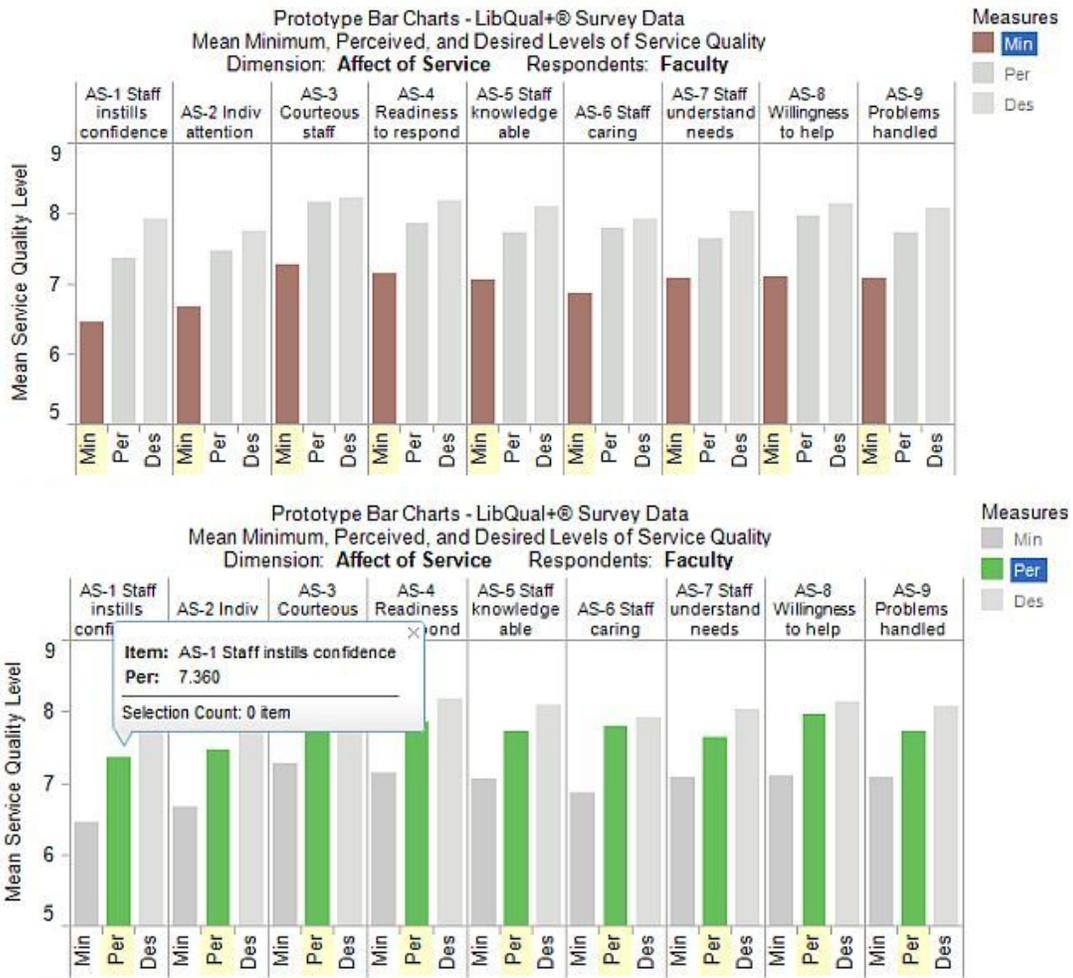


Figure 3C. Tableau Software Interactive Feature: Highlighting Individual Measures

These sorts of patterns can also be identified in LibQual+® radar charts. For instance, in the top chart in figure 5, the yellow affect of service region near the blue-shaded item numbers (top right of chart) represents the superiority gaps for the nine items in that dimension. Note that this

region indicates a notable superiority gap. Comparing that with the same (yellow) region in the lower chart in figure 5, the gap for faculty is much less due to the higher mean levels of perceived service quality. In this same manner, users may identify specific patterns in radar charts which can then be explored using bar charts in the general style presented here.

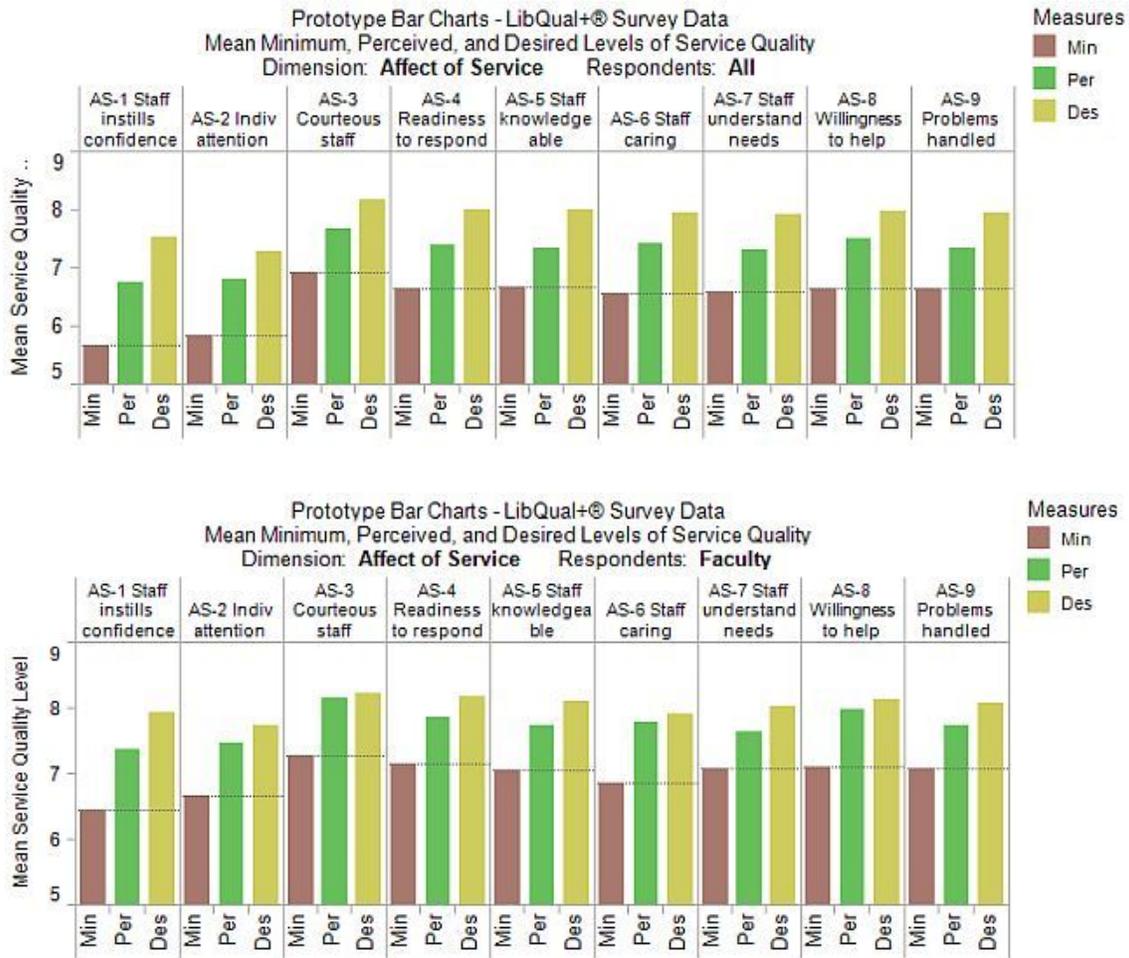


Figure 4. Levels of Service Quality for Affect of Service Items, All Respondents and Faculty

In a more compact arrangement, bar charts can display data pertaining to a single LibQual+® dimension for all respondent groups, as seen in figure 6. Presenting the data in a single graphic allows for visual inspection of patterns within and among groups. As an example, looking at mean service quality levels for undergraduate and graduate students in figure 6, we see that:

*Graduate students report slightly higher levels of desired service quality than undergraduates do, especially for the first two affect dimension items. Their mean minimum expectations are slightly (about 0.3) higher than undergraduates. Graduate students report about 0.4 higher mean levels of perceived service quality on all items compared to undergraduates.*

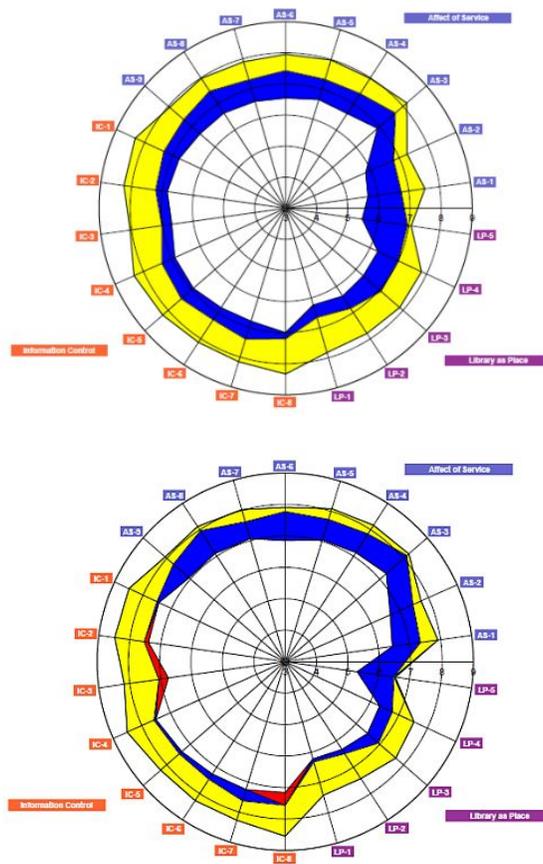


Figure 5. LibQual+® Radar Charts for All Respondents (upper) and Faculty (lower)

Alternatively, service quality levels for a single respondent group can be displayed for each dimension. Figure 7 portrays mean responses for graduate students for each dimension as well as that group’s overall responses for the 22 core items.

The relative sizes of adequacy and superiority gaps can also be presented in bar chart format. Figure 8 depicts mean adequacy gaps in order by the three LibQual+® dimensions for each respondent group.<sup>4</sup> The bar color-coding matches the scheme seen in the radar charts’ item identifiers (see figure 5 and standard LibQual+® notebooks).

<sup>4</sup> It is important to note that none of the bar charts presented in this paper contain certain key information which radar charts always contain, namely (a) the mean minimum levels against which mean perceived levels are compared to calculate the adequacy gaps; and (b) mean desired levels against which mean perceived levels are compared to calculate the superiority gaps.

Prototype Bar Charts - LibQual+® Survey Data  
 Mean Minimum, Perceived, and Desired Levels of Service Quality  
 by Respondent Group  
 Dimension: **Affect of Service**

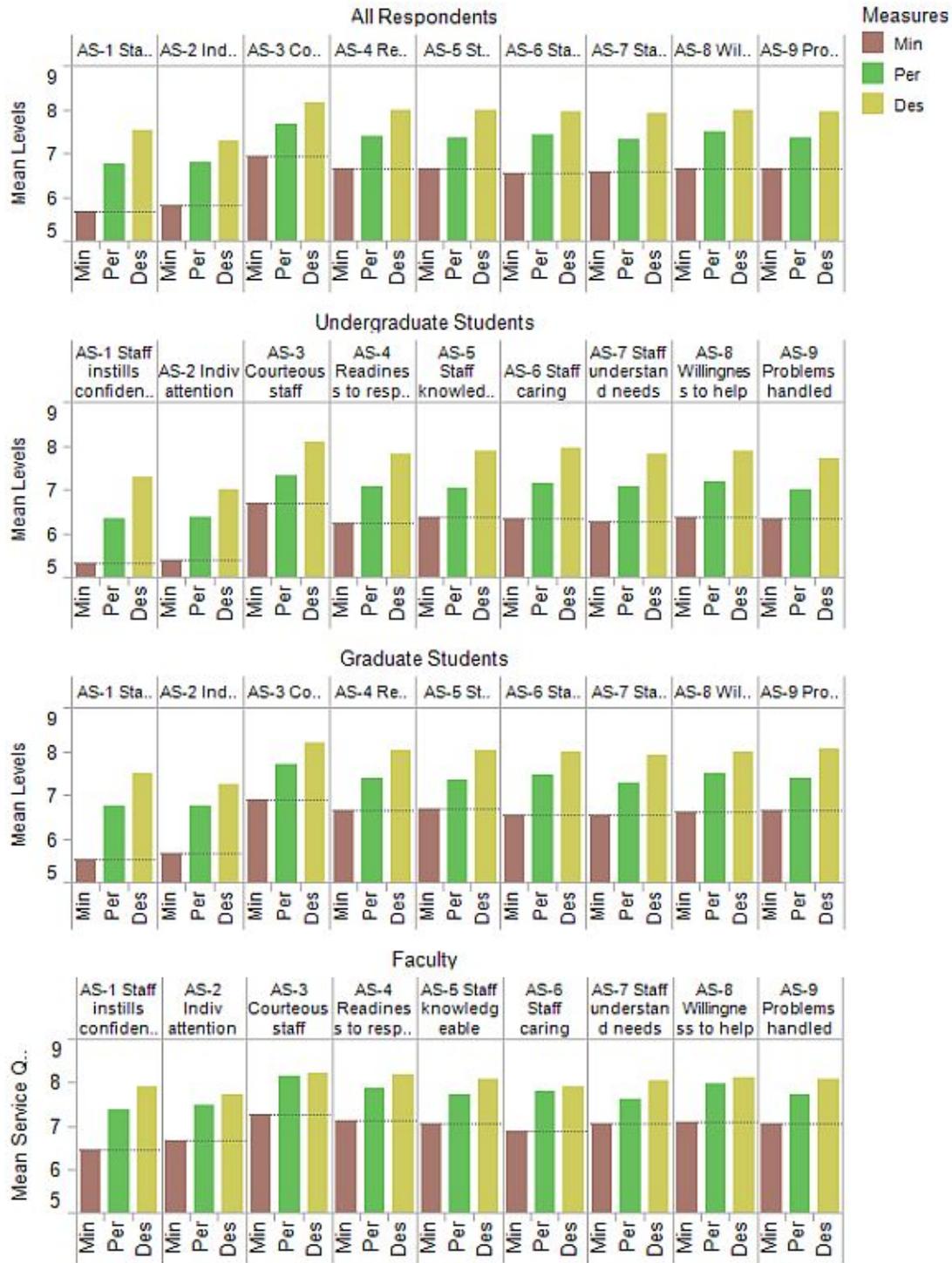


Figure 6. Multiple Bar Charts Enable Comparisons of Data Within and Between Respondent Groups

Prototype Bar Charts - LibQual+® Survey Data  
 Mean Minimum, Perceived, and Desired Levels of Service Quality for All Dimensions  
 Respondents: Grad Students

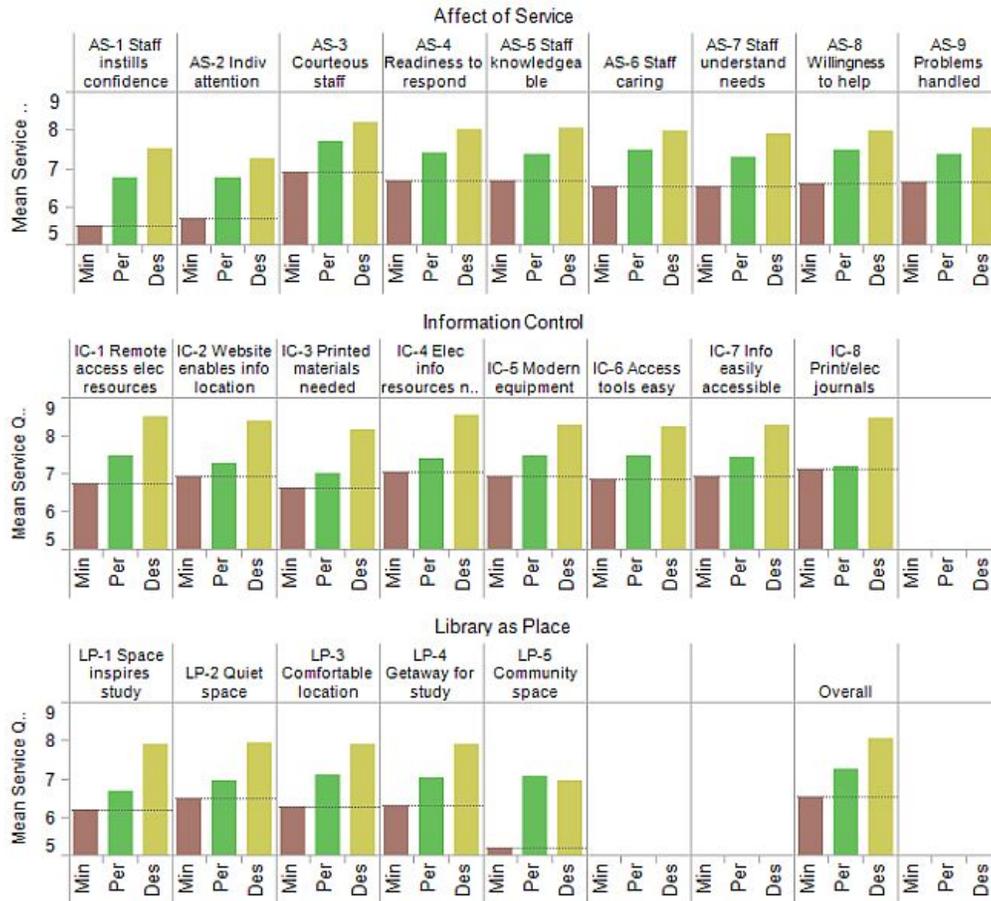


Figure 7. Multiple Bar Charts Depicting the Three LibQual+® Dimensions for a Single Respondent Group

Because these charts utilize a stationary zero baseline (see figure 8), they provide an intuitive representation of the survey data. Being exact representations of gap sizes, the bar heights make comparisons easy. Since the axes scales indicate positive and negative values, color could be used in these charts to encode additional information, if desired. In radar charts, color is reserved to indicate positive versus negative gaps and superiority versus adequacy gaps.

Sorting mean adequacy gaps may also lead to other insights, as illustrated in figure 9. For instance, in the top chart in that figure (all respondents) it is clear that adequacy gaps are larger, overall, for the affect of service dimension than for information control. Of course, this pattern is evident also in the top radar chart of figure 5. However, figure 9 enables a more straightforward comparison of these magnitude differences.

Since superiority gaps are typically negative, the zero baselines for charts in figure 10 appear at the top of their vertical axes. The bars extend downward and the vertical axes values reflect decreasing negative numbers (and increasing negative magnitudes). One exception appears in the lower chart, where, for graduate students, item LP-5 shows a positive superiority gap.

Charts in the styles seen in figures 8 and 10 can be combined into a single graphic portraying adequacy and superiority gaps together. This combination is presented in figures 11 through 14, which re-express the same data portrayed in the concentric areas of radar charts. Keep in mind that in radar charts superiority gaps (negative numbers) are located higher on the radiating scales, towards the outside of the circle. Adequacy gaps (positive numbers) are located lower on the scales, closer to the center (see figure 5). The orientation of the bar charts is the inverse of this. That is, the chart scales are upside down compared to LibQual+® radar chart scales. (Or radar chart scales could be considered upside down since negative values are plotted above positive ones.)

In figures 11 through 14 the heights of bars (whether above or below the zero baseline) correspond exactly with the thickness of the color-coded spokes on the radar chart as illustrated in figure 15. Chart regions in these figures, rendered in pastel yellow, blue, green, and pink, follow the basic color scheme of radar charts. Additionally, the bar colors match the three LibQual+® dimensions, as do bars in figures 8 – 10 also.

When data include negative adequacy gaps or positive superiority gaps, the zero axes for the two categories do not coincide (see figures 13 and 14). Nevertheless, visual comparisons of bar lengths in the upper and lower portions of these charts are fairly clear-cut. Notice also in figure 13 that one item (LP-5) has a positive superiority gap indicated by the thin pastel green region. Figure 14 includes a pastel green region highlighting that same item (LP-5). Also in that figure, three items (IC-2, IC-3, and LP-1) show negative adequacy gaps in the highlighted pink region.

In sum, the chart styles in figures 11 through 14 are useful because they *re-present* the same data that radar charts display in a simpler and more readable format. As indicated earlier, the charts can be used in tandem with radar charts to investigate any patterns of interest noted in either format.

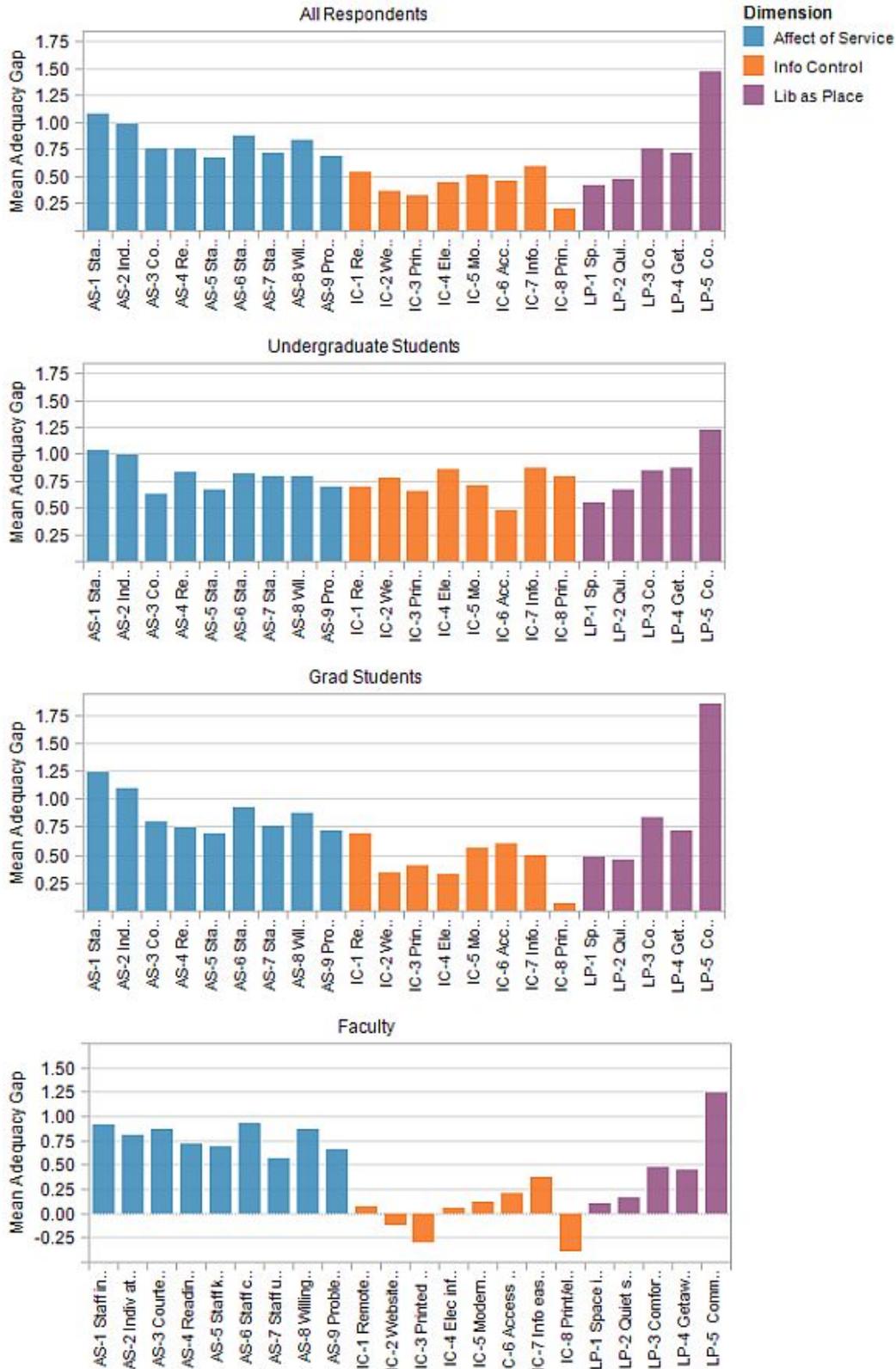


Figure 8. Mean Adequacy Gaps for 22 Core Items by Respondent Group

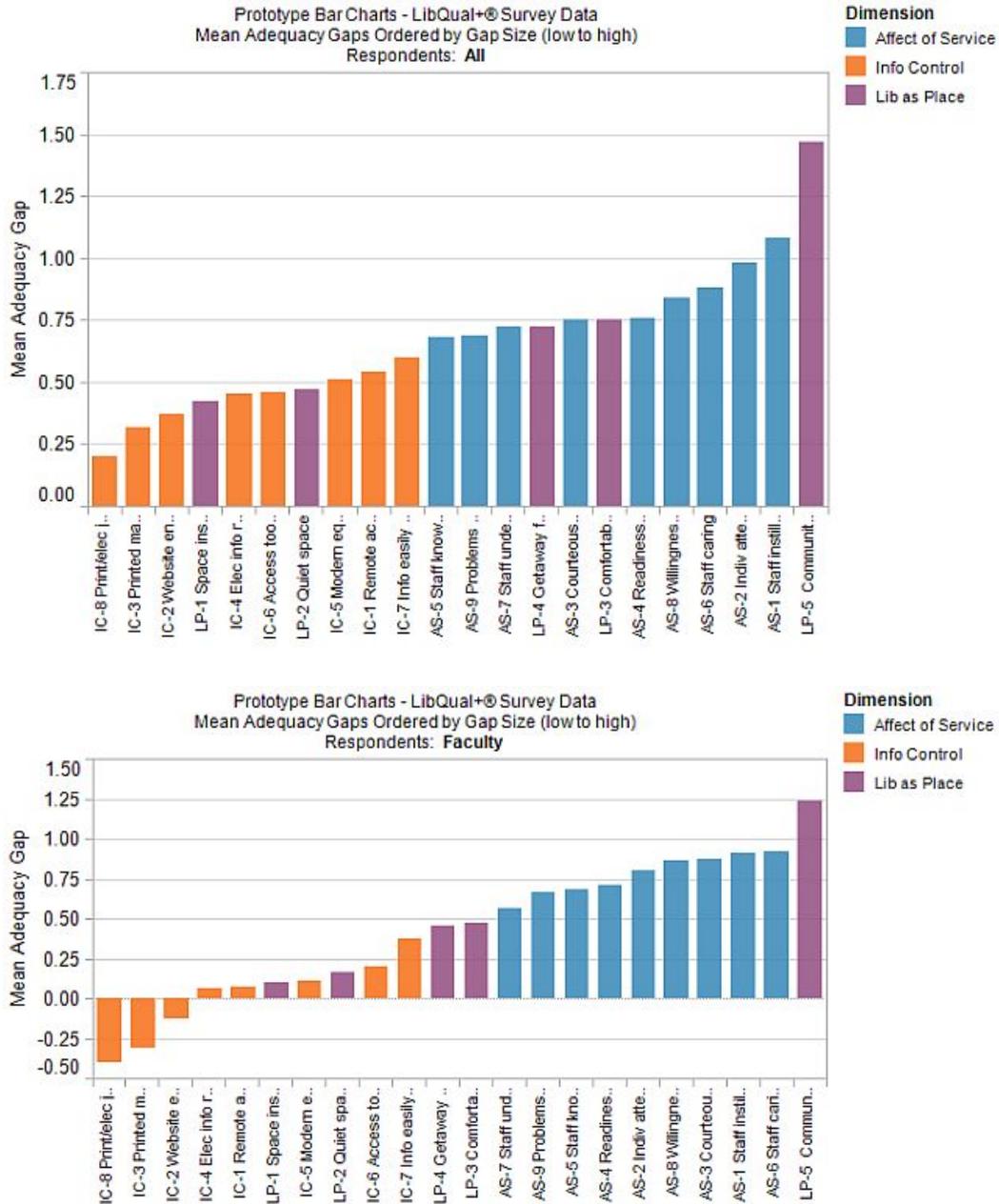


Figure 9. Adequacy Gaps Sorted by Size for All Respondents and Faculty

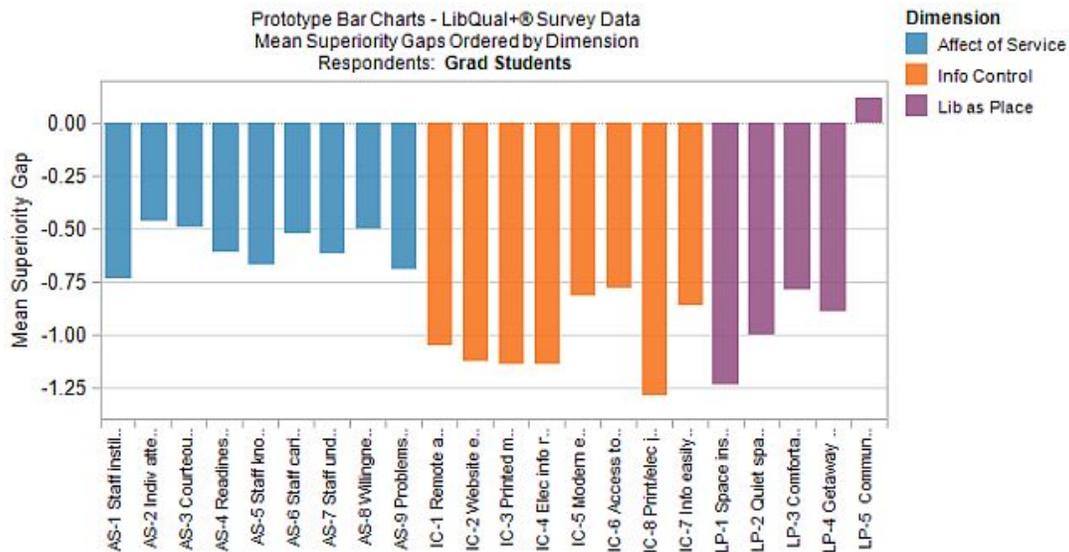
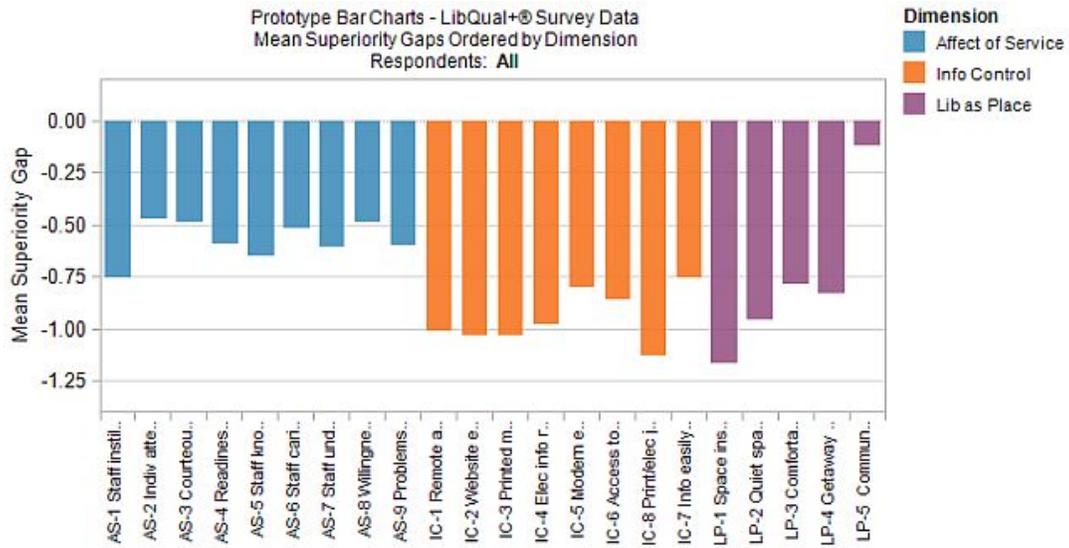


Figure 10. Mean Superiority Gaps for All Respondent and Graduate Students

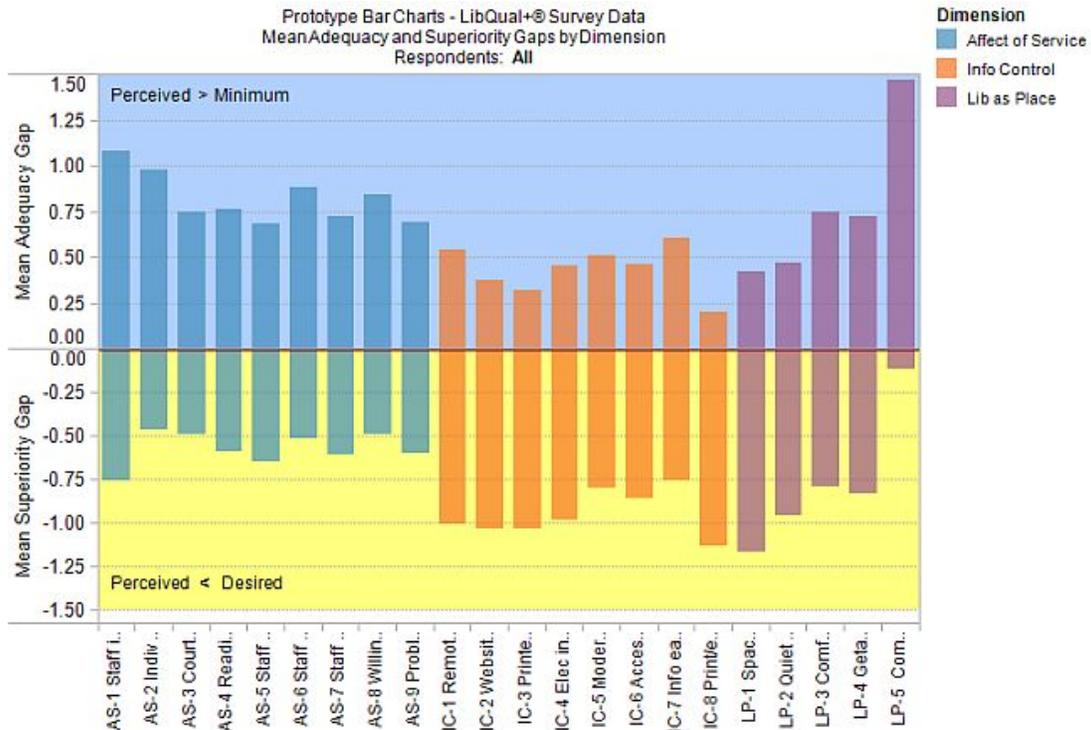


Figure 11. Mean Adequacy and Superiority Gaps for All Respondents

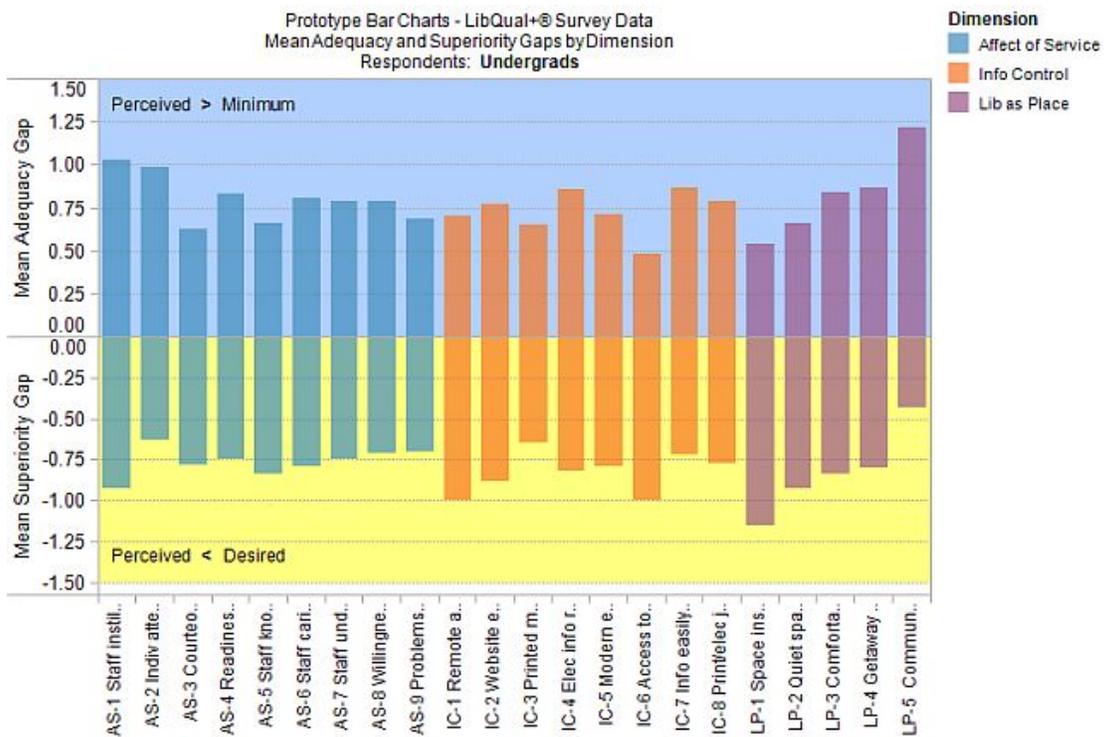


Figure 12. Mean Adequacy and Superiority Gaps for Undergraduate Student Respondents

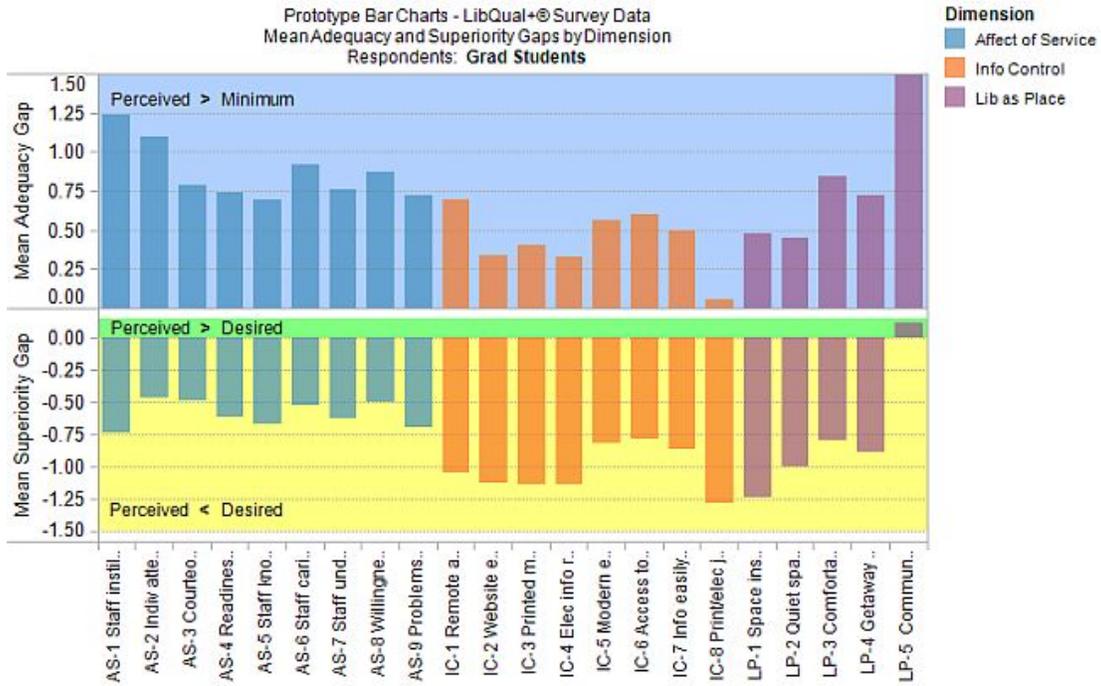


Figure 13. Mean Adequacy and Superiority Gaps for Graduate Student Respondents

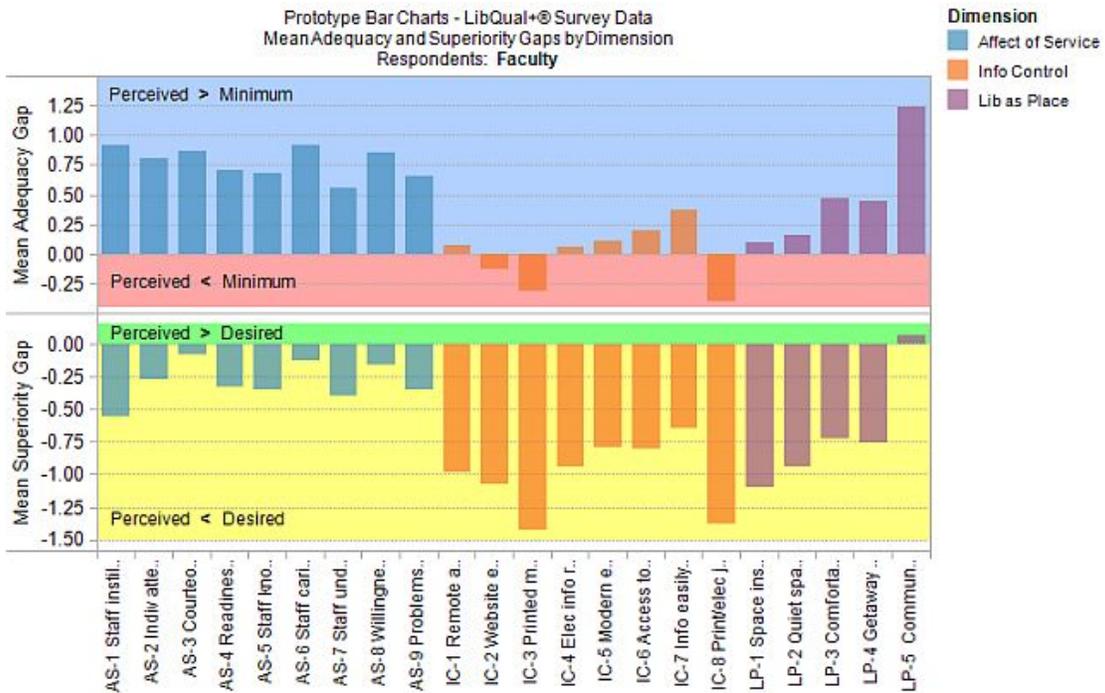
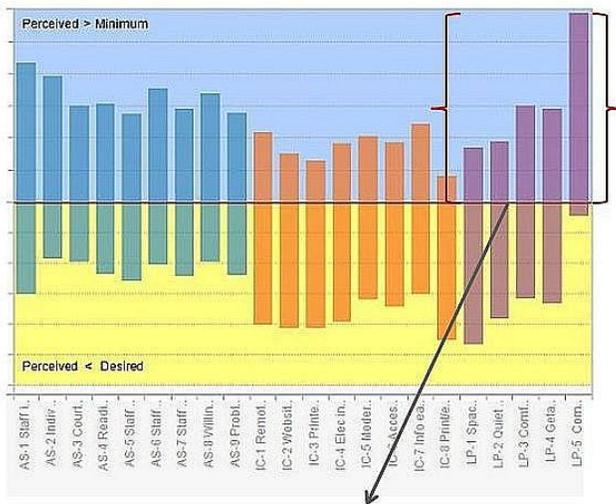
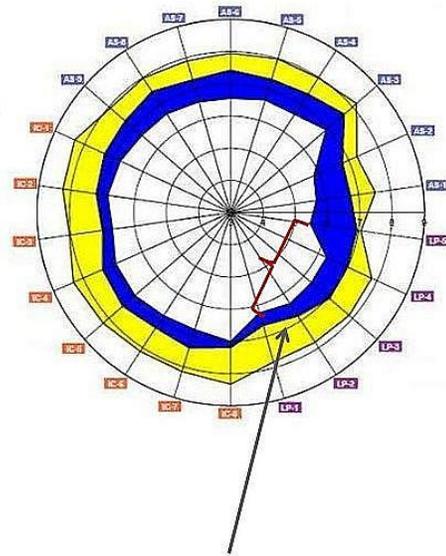


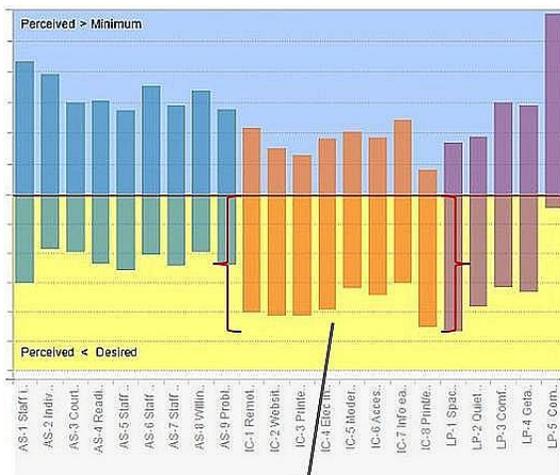
Figure 14. Mean Adequacy and Superiority Gaps for Faculty Respondents



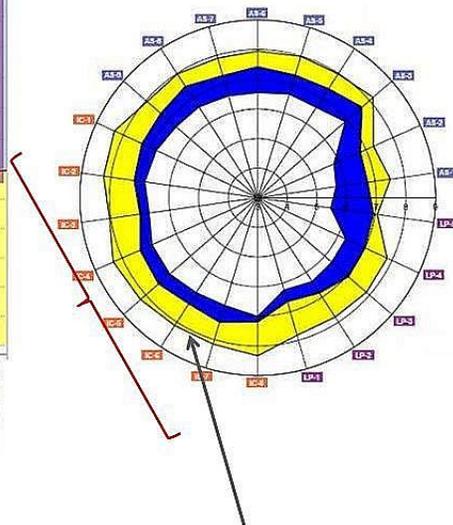
Lengths of these library as place adequacy gaps correspond with ...



... the thickness of blue library as place region here.



Lengths of these information control superiority gaps correspond with ...



... the thickness of yellow information control region here.

Figure 15. Bar Lengths Correspond with Thicknesses of Specific Portions of Radial Charts

## Exploring Data Variability Using Histograms

John Tukey (1977, p. 27), the grandfather of data visualization, wrote:

Summaries are very useful but they are not the details. So long as the detail is not so great as to confuse us hopelessly, there will be no substitute for having the full detail where we can look at it.

When analyzing LibQual+® service quality ratings and gaps, libraries should be cognizant of details underlying the data, that is, the *data distributions*. The simplest tool for visualizing data distributions is the standard histogram. For example, figure 16 presents two histograms with ratings of minimum, perceived, and desired quality levels for survey Item AS-2 for all respondents. The two rows in the figure are identical, except that mean values are annotated in the lower row. Notice in either row that responses for desired levels are skewed towards the left, whereas for perceived and minimum measures they are more spread out. Mean values reflect this fact in that the mean perceived rating (6.8) is further left than the mean desired rating (7.2). Yet, these two figures hardly describe the real spread of the data. But looking at the histograms does.

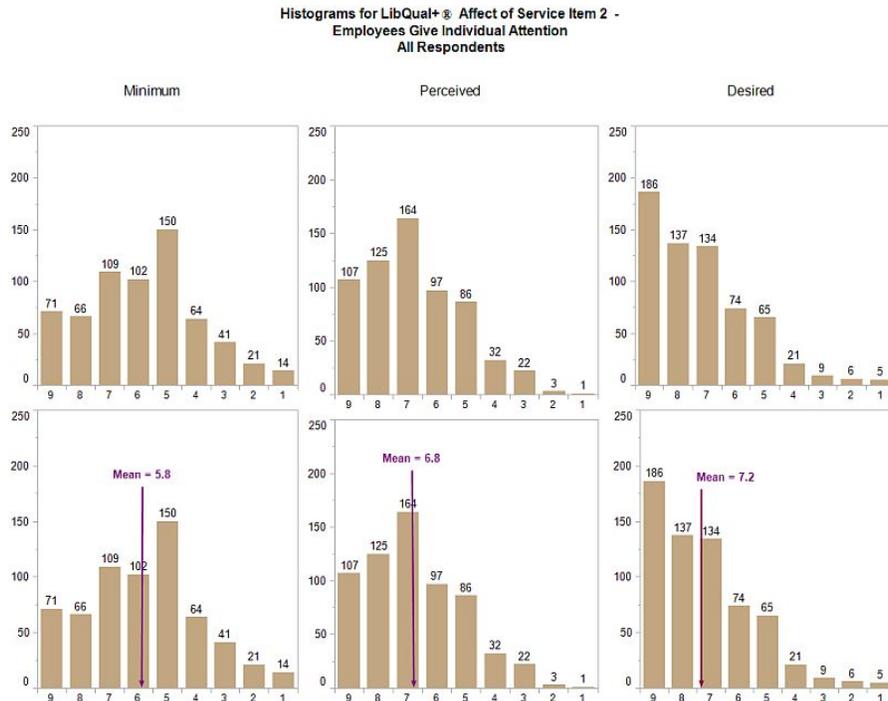


Figure 16. Histograms Show Data Variability

Thus, it is crucial that libraries generate histograms for each survey item, for each respondent group, looking for patterns that may be unique to any given combination of items and groups. In many of these charts, the libraries may observe that the majority of responses cluster together. For instance, in many cases mean desired levels may routinely approach 8 or 9. And there will also be other patterns which the majority of respondents tend to follow. Still, patterns unique to the minority of respondents require attention also. Histograms and similar graphs (like *box plots*) that show the distribution of survey responses will reveal these minorities. Beyond this, histograms from different survey years should be examined to identify trends among these minority responses over time.

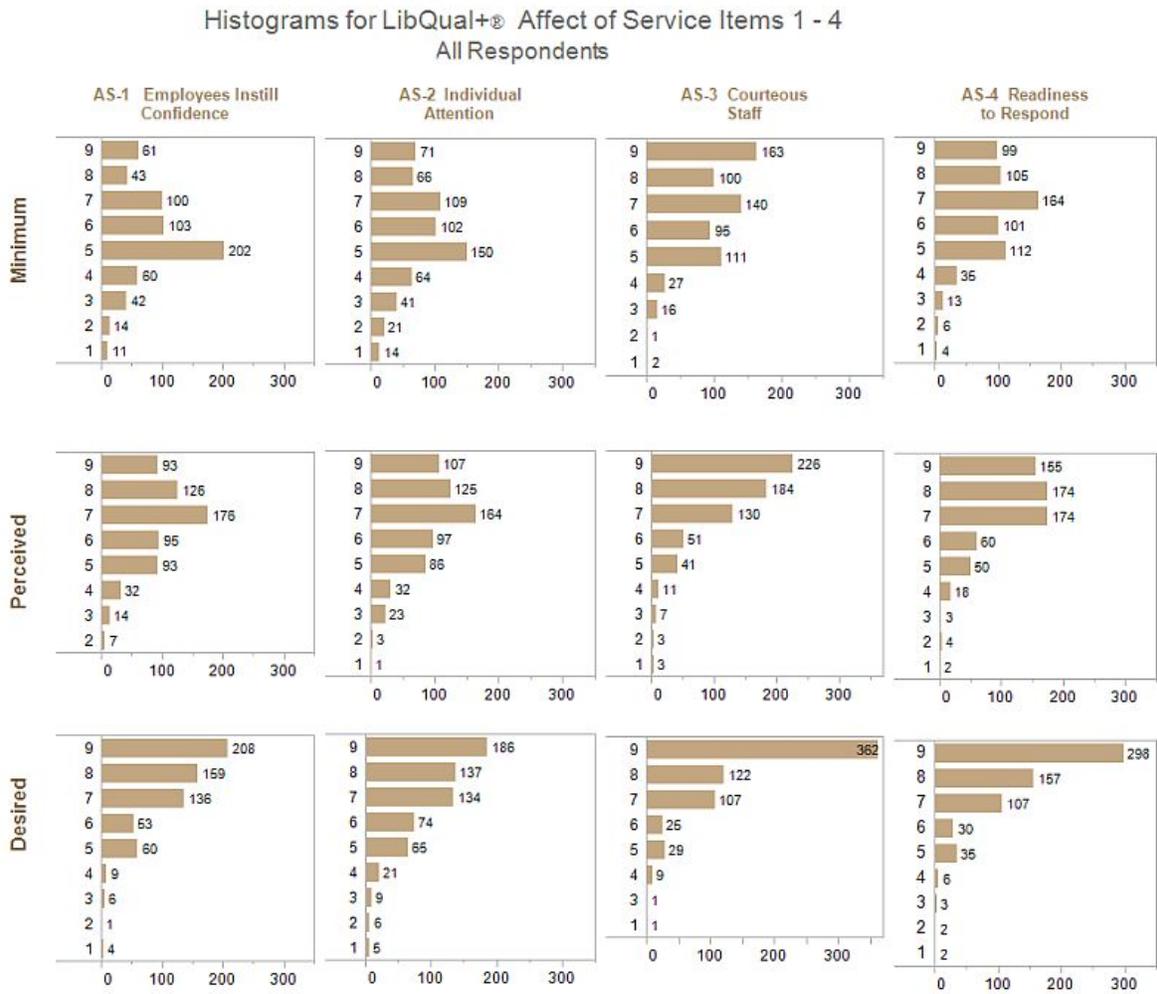


Figure 17. Histograms of Items AS-1 through AS-4 for All Respondents

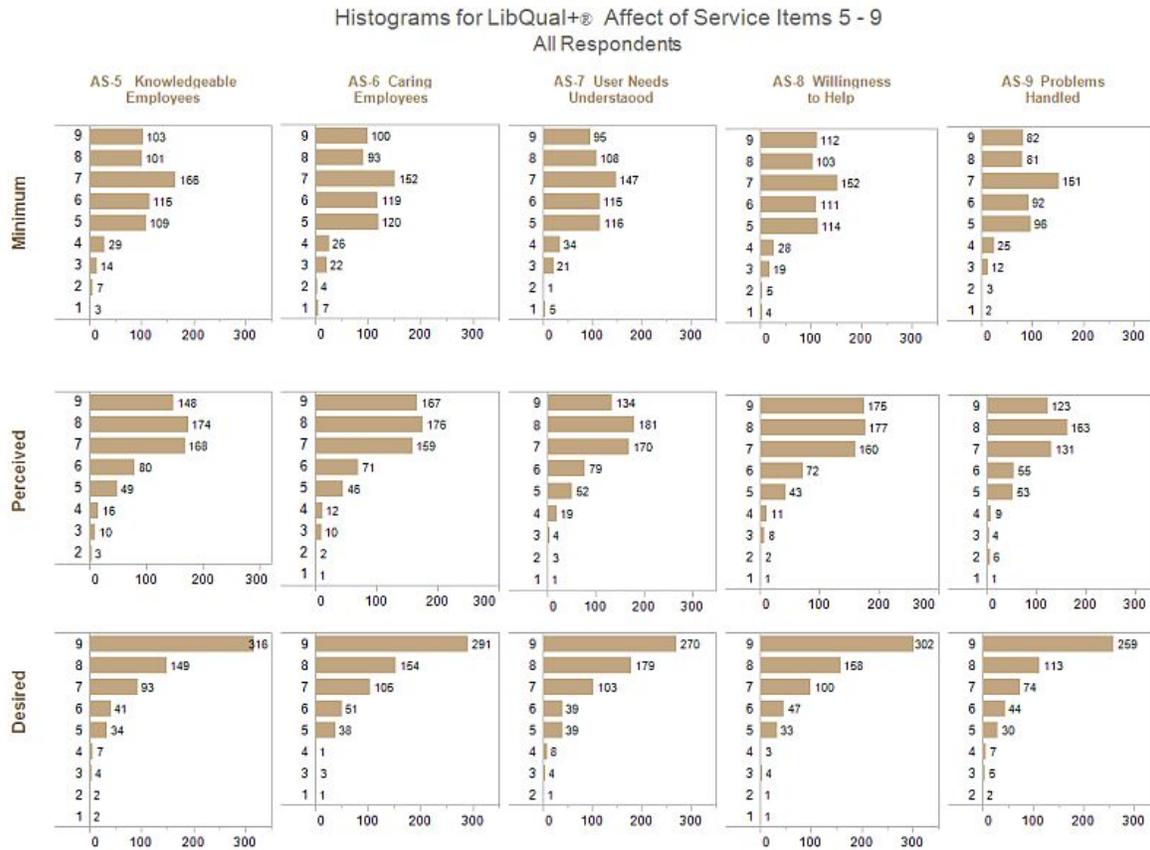


Figure 18. Histograms of Items AS-5 through AS-9 for All Respondents

Again, sleuthing for information in survey data requires looking at as much detail as possible in ways that foster meaningful insights. Figure 17 and 18 provide another example of details worth examining. The figures (referred to as a *trellis display* because they contain multiple small charts) make quick visual comparisons of all nine items for the affect of service dimension possible. They also demonstrate the amount of detail that this process yields. Some displays may produce no information that is news to the library, but others may. As a result, libraries should devise and explore a substantial number of graphs like these, depending on the library's services, respondent groups, and assessment questions.

Use of stacked bars in histograms can help illuminate patterns among subgroups, as figure 19 illustrates. Since visually gauging lengths of stacked bars can be difficult, this chart represents each group in both stacked bars and individual histograms (with aligned zero baselines).

### Histograms for LibQual+® Core Item: AS-2 Users Get Individual Attention

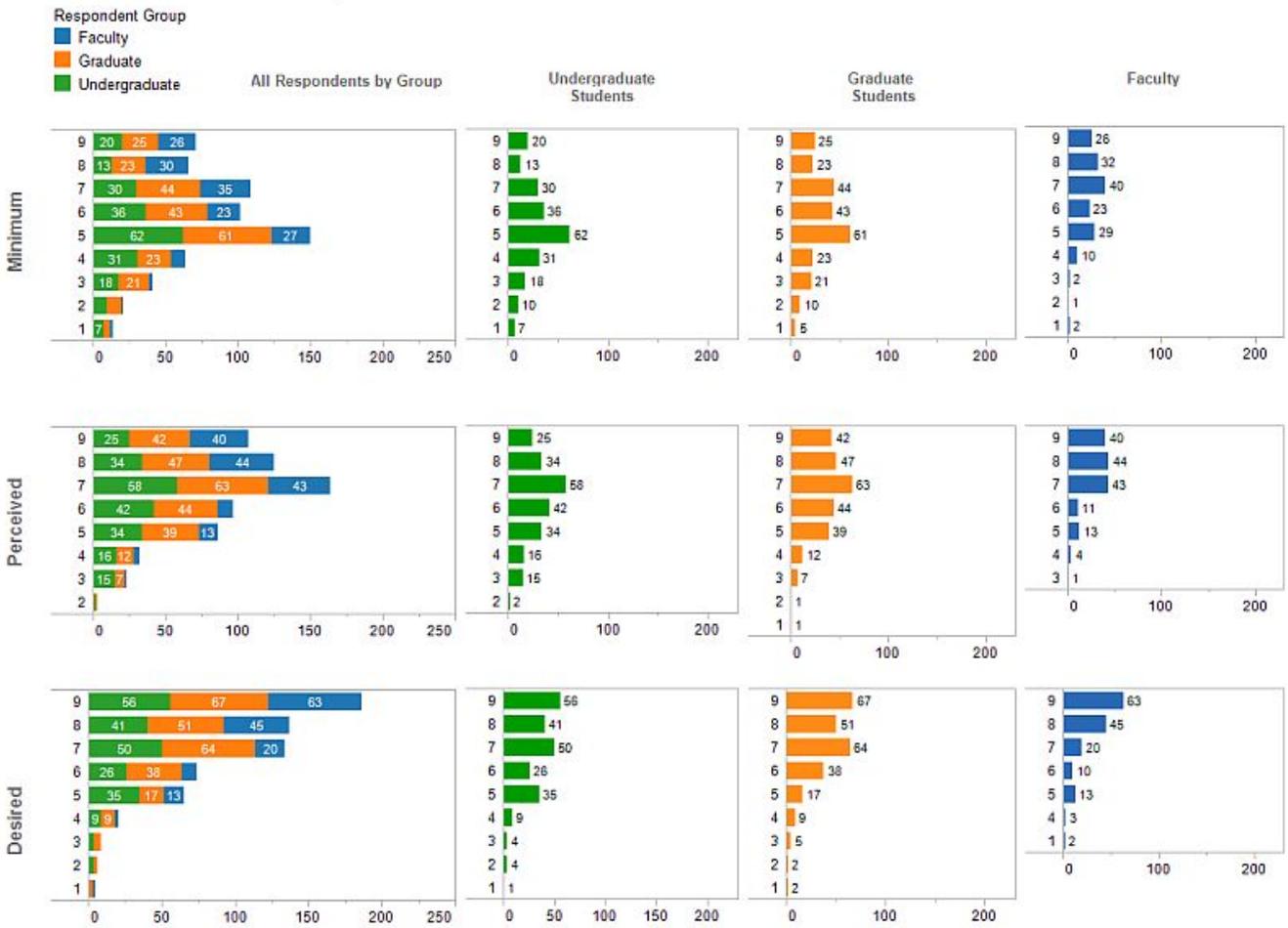


Figure 19. Stacked Bar Histograms and Single Histograms for Items AS-2

### Conclusion

Use of two basic graphical formats—bar charts and histograms—can enhance a library’s understanding of its LibQual+® survey data. Bar charts are simple graphical formats that facilitate accurate visual exploration of details in data. Patterns identified in radar charts, within and across both respondent groups and survey dimensions, can be clarified using charts such as those proposed here. Bar charts can also help uncover patterns that may be obscured by the complexities of radar charts. Histograms provide a clear portrayal of the distribution of survey responses and gaps. Again, these require diligent preparation and detailed study.

These charts have been proposed in hopes of raising interest in pursuing graphical data presentation tools further. The designs and formats are preliminary. Their utility can only be

confirmed by use and refinement by libraries seeking to learn more about their users via LibQual+® data.

### References

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Few, S. (2009), *Now You See It*, Analytics Press, Oakland CA.

Tukey, J. (1977), *Exploratory Data Analysis*, Addison-Wesley, Reading, MA.