Many of us create illustrations for outreach, figures for textbooks, or art for articles. We assume that viewers understand our work. But do they? Research on textbook figures indicates problems. When students are asked to interpret a figure, comprehension rates range from ~25% to 75% (depending on complexity of the topic). Graphs are worse.

**WHAT'S THE PROBLEM?**

There seem to be two main issues: 1) viewers don't follow basic diagram conventions like reading labels or titles or following arrows, and 2) viewers with little background knowledge pay attention to unimportant details and ignore important ones. If students do observe the important details, they often don't translate that information into comprehension of the topic.

So the idea is... if we can teach students to follow diagram conventions AND if we can graphically direct attention to important details and explain how they are important, then understanding should increase.

**INSTRUCTION ON CONVENTIONS**

How do you teach students about reading images? One group of researchers developed an instruction booklet and semester's worth of diagrams practice. They expected students to greatly improve their interpretation of figures. However, students showed only a very slight increase. *Personally, I'd be interested in seeing a study that required students to create diagrams in order to learn conventions. But that's a topic for another article.*

**GRAPHICALLY DIRECTING VIEWERS**

Perhaps the key to improving diagram comprehension is graphic design. Designers and illustrators can use elements and text to direct viewers and explain concepts or processes. Let's start with text - how should it be laid out? Which text format works best?

**WHERE'S THE TEXT?**

The one outcome that appears to be universal is that images should be near the appropriate text. Duh, right? But then there's a question of how close. You could have:

- text on one page and image on the next (not good),
- text and image on the same page (Fig.1),
- text incorporated into the image: "spatial integration" (Fig.2).

While some researchers indicate that spatial integration is best, others have shown that this approach may 'dumb down' the image so that viewers don't pay as close attention.

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**Circulation through the Heart**

Blood enters the Right Atrium of the heart from the body, having depleted its oxygen (1). The heart doesn't supply any oxygen to the blood, but can pump the blood out to the lungs. When the heart squeezes, blood leaves the Right Ventricle (2) and travels through the Pulmonary Arteries out to the Lungs.

Having picked up oxygen at the lungs, the blood returns to the heart through the Pulmonary Veins (3). Blood enters the Left Atrium and travels down to the Left Ventricle (4). This time when the heart squeezes, blood is pushed out through the Aorta to supply all the cells of the body with oxygen (5).
The next question is whether the text should be segmented or whole. Most research indicates that segmented text works best for comprehension. And while “spatial integration” requires text to be segmented, this design approach can often look overwhelming or cluttered. Another issue, of course, is that “spatial integration” often requires the artist and writer to work closely together (or be the same person).

**GRAPHIC ELEMENTS AS SIGNALS**

“Signals” include directional techniques like arrows, colors or highlighting that direct the viewer to important aspects of the image. Segmented text and labels can also function as a “signaling technique” But use caution. Multiple studies have shown that, when used in more complex graphics, comprehension levels drop. Researchers suggest only including the most relevant, required visual information.

**TYPE OF IMAGE**

More realistic, concrete objects are easier for viewers to comprehend. Abstract images require more explanation. However, few studies acknowledge that these images often match their messages.

Concepts which can be photographed or drawn realistically, such as anatomy, are usually simpler (e.g. skeletal or flower structures). Comprehension of these topics involves only identification, visual comparison, and an understanding of basic function. More complex topics, like processes (e.g. action potentials in neurons or geological subduction), must be drawn. These concepts require identification of novel structures, functions on very large or very small physical scales or timescales, and a thorough understanding of more general structures.

Graphs can be included in the complex drawing category since they show summaries, patterns, and ranges of outcomes under various conditions. These diagrams are extremely complex and abstract, requiring not just comprehension but interpretation and translation as well.

**VIEWER INVOLVEMENT**

The most interesting research I read describes viewer involvement. In one study, text segments were available but out of order (Fig.3). Viewers had to match the text to the appropriate locations of the graphic. The data looked promising compared to other treatments, but average comprehension still remained in the 50% range. Another study left parts of an image out, requesting students fill in the missing labels, descriptions or structures. Again, the results from this activity indicate that students comprehend more information from these graphics.

**A WORD OF CAUTION**

In all these studies, the averages are used to make conclusions. Makes sense, of course… BUT in looking at the statistical variation, there are HUGE ranges of those averages. And all the ranges overlap. Statistically speaking, none of these techniques seem to make a substantial difference. Maybe something interesting to think about though.
Blood enters the Left Atrium and travels down to the Left Ventricle.

The heart doesn’t supply any oxygen to the blood, but can pump the blood out to the lungs. When the heart squeezes, blood leaves the Right Ventricle and travels throughout the Pulmonary Arteries out to the Lungs.

This time when the heart squeezes, blood is pushed out through the Aorta to supply all the cells of the body with oxygen.

Having picked up oxygen at the lungs, the blood returns to the heart through the Pulmonary Veins.

Blood enters the Right Atrium of the heart from the body, having depleted its oxygen.

**Figure 3:** Example of interactive Text layout

**Postscript:** I ran my own mini-experiment using the three images shown in this article. Contrary to the data presented in other research papers, students who received the "Whole Text" graphic performed best (~63%) on a follow-up test. The "Interactive Text" scored the lowest on average (~53%).

**SOURCES**


**ABOUT THE AUTHOR**

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