Locating Visual Communication across Disciplines: How Visual Instruction in Composition Textbooks differs from that in Science-writing Textbooks

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Abstract: This article shares results from a qualitative research project that examines the similarities and differences in how composition textbooks and science-writing textbooks address visual communication topics. This research has two goals. First, it seeks to better understand how visual communication is practiced and valued in the composition and natural science disciplines by analyzing the visual terms used and themes covered in the textbooks. Second, by exploring differences in disciplinary expectations and conventions, the research demonstrates how visual communication skills taught in FYC may not always be universally valued by all disciplines. This article concludes with insights composition instructors can use to prepare students for the differences in communication practices they will face when writing in the science disciplines, even if FYC does not teach science writing specifically. Likewise, tracking students' learning in FYC would aid WAC/WID instructors and science instructors as they build upon students' prior knowledge and assumptions when teaching the particulars of visual communication.

The disciplinary conventions for visual rhetoric in science writing differ significantly from those often taught in composition courses. Scholarship and instruction on writing in the sciences include significant examinations of the use of visuals. For example, science research writing often requires that written text and visuals work together: both elements convey noteworthy results, and audiences can read and skim both text and visuals to glean main ideas and concepts. Thus, the teaching of visual communication conventions is necessary in science classrooms. However, the ways in which composition studies scholars theorize how visuals are integrated in composition courses emphasize different values from the practices in science writing and instruction. As such, students' knowledge and abilities related to visual data in composition courses might not transfer effectively to writing and reading contexts elsewhere.

Research in the sciences is filled with quantitative, numeric data suited for visual presentation and visual representations of organisms, habitats, and processes occurring in the natural world. Meanwhile, data in composition research traditionally has taken a more qualitative, discursive form. The early work on visuals was perceived to be part of the domain of professional/technical writing and not of composition studies until The New London Group (1996) argued that composition instructors should likewise attend to visuals in a move toward multiliteracies. This introduced research in writing studies to areas of data visualization, aesthetics, and information visualization (infovis) where scholars have studied and designed all types of visuals in a variety of media, argued for new venues to house new media projects, and considered a wide range of challenges that exist for

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composing in new media genres. However, what filtered into classroom practices and textbook instruction was a more limited coverage of visuals.

The WPA Outcomes Statement for First-Year Composition, authored by the Council on Writing Program Administrators (2014), recommends visual communication as a component of composition courses: Students should "attend to elements of design, incorporating images and graphical elements into texts intended for screens as well as printed pages." What often results from this sentiment are visual rhetorical analysis activities or assignments like George's (2002) visual argument in which students create a visual to "make a claim or assertion and attempt to sway an audience" in the form of blogs, podcasts, video essays, collages, photo essays, e-portfolios, etc. (p. 29). These activities are often designed to teach students critical literacies for interacting with the technology and media that "come at our students from all directions, including television and the World Wide Web" (Day, 1997). Such assignments in which students rethink their reading and composing practices for digital and public domains are now common in composition textbooks. But what appears less often are opportunities for students to consider how the composing contexts of academic disciplines impact visual design, and students who lack awareness of how academic conventions impact the creation and reading of visuals might struggle to adapt strategies used in composition to disciplines with data-driven visuals, such as the sciences.

Most scholars currently acknowledge that students' abilities to transfer learning exists in some capacity, yet many debate how it occurs and in what ways instructors positively or negatively influence students' abilities to transfer. Elizabeth Wardle (2009) questions whether composition instructors help students transfer knowledge or skills because she has "found that FYC teachers often mistake the genres of English studies for genres-in-general" (p. 769). Joanna Wolfe, Barrie Olson, and Laura Wilder (2014) agree with Wardle's findings:

> Because instructors primarily teach and study within their disciplines, they come to mistake their specialized disciplinary ways of thinking and writing as universal skills (Russell, *Writing*; Lea and Street; Thaiss and Zawacki; Wilder). No more immune to this tendency, FYC instructors...tend to view their own discipline's values, assumptions, and conventions as the norms in other disciplines. (p. 43)

Logically, then, if instructors do not notice how their instruction promotes communication valued by a certain discipline, students likely do not recognize it either. This becomes a problem if students are expected to transfer what they learn about visual communication from FYC to science writing contexts.

The breadth of visuals found in academic writing across disciplines exemplifies the value of analyzing visual and written communication practices side-by-side. Science disciplines are not the only ones that have specific conventions for reading and composing visuals: disciplines in engineering, fine art and design, and even the social sciences often value information best depicted in charts, graphs, tables, photographs, drawings, or other visuals. Charles Kostelnick and Michael Hassett (2003) note distinctive types of visuals used in a variety of disciplines, writing, "Students entering a discipline such as mechanical or civil engineering take course work that teaches them the visual codes of gears, drive shafts, bridges and topography. Likewise, students in agronomy learn how to read soil diagrams; in forestry, tree plots and maps; and in meteorology, color-enhanced satellite photos" (p. 25). In essence, it would be useful for students to consider how the differences in the methods for conveying new knowledge impact both the researcher/writer's composing processes and the audience's reading processes, particularly where visuals fall within each.

This paper focuses on visual communication practices in the sciences because a natural sciences requirement appears in many U.S. liberal arts college and university curricula, offering an ideal place

to begin examining disciplinary visual communication distinctions that many students will encounter. There is a wealth of textbooks available to instructors in the natural sciences disciplines, including a wide variety of resources and textbooks that teach students about writing practices in the sciences. Additionally, scholars have already begun examining visuals used in science education (such as Ainsworth, Prain & Tytler, 2011; Gilbert, Reiner, and Nakhleh, 2007; Ramadas, 2009) and visualization methods for conveying scientific data (such as Elwood, 2011; Gross & Harmon, 2014; Leydesdorff, 2014; and Mößner, 2018). Textbooks convey not only content but also the authors' approaches for teaching and learning that they and the publishers believe other instructors will want to practice in their own courses and that are valued by the discipline. Thus, this article uses textbooks as a starting point from which information about two disciplines' communication values and conventions may be gleaned.

In this article, I compare visual communication terminology in composition and natural science-writing textbooks to discover the key pedagogical themes that express disciplinary visual communication conventions to students. A thorough examination of these pedagogical themes across the two disciplines' textbooks demonstrates clear distinctions in some disciplinary practices, conventions, and values. The goal of this comparative work is *not* to argue that all composition instructors should explicitly teach their students to practice scientific visual communication. Instead, my purpose is to illustrate that making clear distinctions between the discussions of visuals in the two disciplines' textbooks might help composition instructors with a traditional pedagogical approach teach students to be informed about composition's written and visual communication conventions. And composition instructors with a WAC/WID approach might be able to offer students greater awareness of the communication expectations in science disciplines.

Methods

To begin, I rejected textbooks that solely focused on themes of public science communication, on genres such as oral presentations or posters, or on interactive and web-based visuals since even with technological advancements, most academic and scholarly texts "remain rooted in print traditions" with static data visualizations (Sopinka et al., 2020, p. 2). Then, starting with composition textbooks used in my current and previous universities' composition programs, I searched those textbooks' publishing companies' websites to compile a list of composition and WAC/WID textbooks. I identified textbook titles that emphasized visuals or WAC/WID pedagogies, but I did not limit myself to only those items. I excluded all readers as well as any older textbooks published prior to 2012.

Natural science-writing textbooks and handbooks were initially chosen on the basis of Library of Congress subject headings, specifically "technical writing," "Technical writing -- Handbooks, manuals, etc" and "communication in science." I likewise eliminated books published before 2012, dealing with disciplines outside the natural sciences, or concentrated on highly specialized acts, such as *Writing Reaction Mechanisms in Organic Chemistry*.

Using these initial lists, I searched two university libraries for electronic or physical copies of the textbooks, and used the library services to order copies of those not available. This process led me to related textbooks located on nearby library shelves or with similar titles on electronic searches. Ultimately, I accessed 36 composition textbooks and 32 science-writing textbooks to determine the ways they teach visual communication. After a brief preliminary review of the table of contents and indexes for chapters, sections, or terminology related to visual communication, I found that all of the composition textbooks and 24 of the science-writing textbooks had discussions of visuals. Appendices A & B catalog the 36 composition textbooks and 24 science-writing textbooks examined, respectively, organized alphabetically by publisher.

The composition textbooks are directed toward first or second-year undergraduate students taking FYC courses. However, the science-writing textbooks have a much greater range in audiences, from

undergraduates in *Writing Undergraduate Lab Reports: A Guide for Students* to graduates and early professionals in *How to Write and Publish a Scientific Paper*. Limiting the science-writing textbooks to only those written for an undergraduate audience would not have left a large enough sample size for comparison; however, that distinction does impact the results, and is discussed throughout this article.

To create a nuanced examination of visual communication instruction, I implemented a grounded theory approach to analyze the 60 textbooks. I created a list of visual communication terminology and through a recursive process, examined the indexes of ten composition and five science-writing textbooks to create a final list of 31 terms that appeared in at least two of the textbooks. Using this list, I scanned all of the textbooks' indexes to identify which included each term. It should be noted that I did not do a full corpus analysis of every page of the textbooks, so some terms might be used even though they do not appear in this list. My goal in searching only the indexes was to locate terms that the authors most valued.

Finally, I scanned all sections and pages in the textbooks in which the 31 terms appeared in order to identify themes. I used an open coding process to gain a sense of "where to start, what to look for, and how to recognize it when [seen]" (Strauss and Corbin, 1998, p. 223). Codes were designed based on the patterns of discussions and instructions of the use, analysis, and incorporation/creation of visuals occurring in those sections and pages. I grouped like categories together and coded for eight confirmed visual communication themes. This process uncovered where, how often, and in what ways these discipline's textbooks discussed and valued which visual communication themes.

Results and Discussion

When comparing the 60 composition and the natural sciences textbooks, I identified terms and themes. An examination of 31 terms illustrated that neither individual words used to discuss visuals nor their definitions are employed consistently within or across the two disciplines. Similarly, the eight visual communication themes discussed in the textbooks did not appear in standard ways. In the following section, I delve more deeply into how many of each disciplines' textbooks cover each of these terms and topics and how that coverage is compared.

Terms

Table 1 illustrates the list of 31 key terms found in the 60 composition and science-writing textbooks' indexes, noting how many appeared in each discipline's textbooks. Two overarching observations about the terms are noteworthy. First, not all terms were used consistently in both disciplines' textbooks. Some terms, such as "scatterplot" and "histogram," which are specialized types of visuals, are not used at all in composition textbooks. Meanwhile, visual terms that focus on rhetorical elements (e.g., "visual rhetoric"), elements of document design (e.g., "color"), or general modes of communication (e.g., "(multi)media") appeared less frequently in science-writing textbooks. Finally, terms such as "graph," "figure," "illustration," and "table" were used regularly in both composition and science-writing textbooks, which seem to indicate that they are more standard, universal identifiers for academic visuals. These distinctions point to the different content, audiences, and purposes of science and composition courses, where composition courses provide students tools for composing, typically with the intention that what they learn will be taken with them and used in a variety of future writing situations, and science courses help students practice science by learning how to research and compose within the discipline's boundaries and expectations.

Table 1. Key Visual Communication Terms in the Composition and Science-Writing Textbooks

Key Term	Composition Textbooks	Science-writing Textbooks
Caption	6	9
Cartoon	12	1
Chart(s)	15	10
Color	16	4
Design	17	5
Diagram	8	4
Display	1	4
Drawing	5	5
Equation	0	3
Figure	13	16
Font	15	7
Graph	19	17
Graphic	19	8
Histogram	0	5
Illustration	16	11
Image	23	5
Map(ping)	26	7

Key Term	Composition Textbooks	Science-writing Textbooks
(Multi)media	24	5
(Multi)modal(ity)	15	0
Photo(graph)	23	6
Scatterplot	0	5
Symbol	10	4
Table	18	18
Visual	30	6
Visual analysis	8	0
Visual argument	10	0
Visual communication	3	0
Visual element/image	9	6
Visual evidence	2	1
Visual rhetoric	9	1
Visual text	7	0

Second, certain terms might have multiple definitions or be used interchangeably with others in one or both disciplines' textbooks. For instance, certain composition textbooks used non-visual definitions of terms: "figure" as a figure of speech, "illustration" as a visual or written depiction of an idea, and "symbol" as a written representation of another word. In both disciplines' textbooks, "map" was used in a variety of ways: to denote an invention technique, describe a reading/analysis/outlining technique, signify a visual representation of an area, or preview a writer's main ideas for a paper. Meanwhile, various definitions of "map" might also be used interchangeably with terms such as "process flowchart," "tree diagram," "graphic organizer," or "cluster diagram" in the composition textbooks. "Visual," similarly, was often used interchangeably with "image," "illustration," "figure," and "graphic."

How these terms are used to denote certain, sometimes similar and sometimes different, meanings highlight Mark Waldo's (2004) claims that each discipline has specific languages that are used in unique ways and that because of those distinctions, academics "are mostly unable to talk to one another, at least in the languages of our work" (p. 3). For students who are novices to discipline-specific academic writing conventions and terminology, these distinctions indicate potential instances of confusion if they are not spelled out. Though not examined specifically in this article, these sorts of differences in terminology might also begin to provide insight into the conventions and expectations of the composing practices of each discipline.

Themes

Using the terms to locate discussions of visuals in each textbook, I identified eight common themes and describe below how the textbooks demonstrate each theme. These themes are as follows:

1. Purposes visuals serve
2. Visuals and written text work together

3. Visuals stand alone
4. Visual design and creation
5. Writers might start with visuals
6. Ethical use of visuals
7. Analysis of visuals
8. Reading visuals

1. Purposes visuals serve

When considering the purposes visuals serve, the science-writing and composition textbooks comprise two topics. First, both disciplines' textbooks cover how visuals function in relation to the researcher/writer, reader, and the written text (see Table 2). However, differences appear in the portrayals of each. For instance, the science-writing textbook examples demonstrate visuals as integral components to science communication: presenting the story and evidence impact the processes of thinking and composing. Meanwhile, the composition textbooks offer more generalized descriptions and highlight visuals in popular as well as academic texts. These generalities likely result from the audience for the textbooks, as students in composition classes tend to be first- and second-year undergraduate students not yet acclimated to university-level critical thinking or academic writing and reading processes. However, science-writing textbooks are not universally directed to novices with little awareness of the conventions of scientific writing. They often start with the assumption that visuals communicate information, which means they can dedicate more space to explaining precisely how images engage and inform the readers with data, relationships, and trends.

Table 2: Purposes visuals serve: How visuals function…

25 of 36 Composition Textbooks (69.4%)	**17 of 24 Science-writing textbooks (79.8%)**
...for the researcher Images function to communicate "how someone is feeling, to instruct, to persuade, and to entertain, among other things." (Ball, Sheppard & Arola, 2018, p. 15)	...for the researcher Scientists use visuals "to illustrate the story, present evidence to support or reject a hypothesis, and record important data and meta-data. We verify, analyse, and display data to share, build, and legitimize new knowledge….Data presentation is also an exercise in deciding which datasets or details to leave out of the article." (Cargill & O'Connor, 2013, p. 25)
...for the reader "Images can function like words, sentences, and paragraphs to help readers understand a writer's main idea." (Mauk & Metz, 2019, p. 91)	...for the reader Visuals can impact readers, "from attracting the attention of potential readers, conveying an emotional tone of new information, to even serving as an additional avenue for readers to retain the information of a piece." (Markovac, Kleinman & Englesbe, 2018, p. 133)

...in relation to written text	...in relation to written text
"As you draft, you may decide that support for your thesis could come from one or more visuals…carefully choose visuals to supplement your writing." (Kutz, Paster, Pulver, 2018, p. 79)	"Data are often presented in tables or figures, and the text will simply serve to tie the data to your objectives or to call attention to main points in the data display. The most critical content of results in many papers are the figures and tables." (Davis, Davis, & Dunagan, 2012, p. 84)

Interestingly, composition textbooks can also imply that visuals are secondary to the written text, as seen in the third row of Table 2. This passage suggests that writers start with written text and add a visual if words alone will not suffice in presenting meaning. The assumption that messages exist primarily in written text does not appear in the science-writing textbooks, and, as seen above, is sometimes challenged with observations that the central data are presented in the visuals. This perspective of visuals is perhaps not surprising since "in academic disciplines such as English and philosophy, the implicit message is that visuals are less important than words….Writers who rely mainly on words think of images as ways to illustrate what they write verbally" (Ward & Vander Lei, 2012, p. 38).

The second topic of this theme covers how the function of visuals can differ with their type. Table 3 demonstrates that science-writing textbooks describe how visuals are used to present technical and scientific information. While some of the composition textbooks describe how visuals present precise data, more focus on how visuals make rhetorical appeals. They also consider academic as well as popular visuals. Though presented differently, the instructions in these textbooks help students understand the roles of certain types of visuals within particular contexts and help them decide what visuals to use in their own writing.

Table 3: Purposes visuals serve: The function of visuals differs

14 of 36 Composition Textbooks (38.9%)	**8 of 24 Science-writing textbooks (33.3%)**
Attention to rhetoric Visuals "make emotional appeals, such as a graph of experimental data; emotional appeals, such as a photograph of a hungry child; and ethical appeals, such as a corporate logo." (Maimon, Peretz & Yancey, 2016, p. 139)	Attention to technical data "Favour graphs to tables when you present experimental data. Tables are appropriate for lists or when there is little data." (Patience, Bonito & Patience, 2015, p. 90)
Attention to popular visuals Photographs and illustrations "might be used to support an argument or illustrate a story, as in essays or newspapers and magazine stories. They also serve multiple roles in websites, posters, brochures, advertisements, comics and political cartoons." (Nicotra, 2018, p. 68)	Attention to scientific visuals "A table can help you compare the results of a variety of chemical analyses. A graph can illustrate the effect of temperature on the growth of bean seedlings. A line drawing can depect an aggressive interactions between two fish, and a photograph can record important features of your study site." (McMillan, 2017, p. 43)

In sum, distinctions exist in the ways the topics are discussed even though both disciplines' textbooks cover similar topics about how visuals function. Such differences likely result from composition textbooks needing to prepare early-stage students for composing in a wide variety of academic and

real-world situations. Meanwhile, science textbooks can focus on conveying detailed communication conventions utilized in a defined set of fields to an audience that has more knowledge about those conventions, or at least about academic writing conventions more generally.

2. Visuals and written text work together

As mentioned in the previous section, visuals in academic documents present key information, but to be more specific, both disciplines' textbooks indicate that the visuals and written text must work together to convey the writer's points. Table 4 illustrates the textbooks, identifying that while the visual and written text have different functions, they must interact to convey all aspects of the message. Both disciplines' textbooks also indicate that if the written text is duplicating information in a visual, or if an idea, concept, or data could be expressed more concisely in a visual, the written text should be deleted (or vice versa).

Table 4: Visuals and written text work together: Visuals and written text serve different purposes

16 of 36 Composition Textbooks (44.4%)	15 of 24 Science-writing textbooks (62.5%)
The written text should "make clear how the visual supports the claim you are making." (Glenn & Gray, 2018, p. 42)	The visual cannot "replace the main text," and the writer cannot leave the act of interpreting the data represented in the visual to the reader. (Boyle & Ramsay, 2017, p. 89)

Table 5 indicates that the two disciplines' textbooks align in their descriptions of document design: that visual decisions made to a document can aid the reader's comprehension and ability to follow the document's organization by using elements such as heading hierarchy and alignment, bold text, white space, and bulleted lists. Relatedly, both disciplines' textbooks discuss the need for all visuals to have written titles, labels, and/or captions that are formatted clearly and consistently.

Table 5: Visuals and written text work together: Document design impacts the content

13 of 36 Composition Textbooks (36.1%)	9 of 24 Science-writing textbooks (37.5%)
"Every paper uses some degree of visual persuasion, merely in its appearance. Consider these elements of a paper's 'look': title page; margins…double-spacing for the reader's convenience; headings and subheadings that indicate the progression of the argument; paragraphing; and so on." (Barnet, Bedau & O'Hara, 2017)	"A figure caption should never begin with a statement that simply repeats the axis labels. Rather, the caption should reflect the specific question that the figure addresses." (Pechenik, 2016, p. 163)

As seen with the previous theme, composition textbooks give more general and varied explanations of how visuals and written text function together, often focusing more on rhetorical descriptions, than the science-writing textbooks do. Overall, however, there appears to be uniformity in the presentation of this theme across the two disciplines' textbooks, indicating that the conventions for illustrating data and helping readers understand their significance in academic articles are not wholly discipline-specific.

3. Visuals stand alone

At the same time that some textbooks provide explanations that visuals and written text must function side-by-side in academic documents, Table 6 indicates that at times the science-writing textbooks articulate the notion that visuals are so important they must stand alone.

Table 6: Visuals stand alone

0 of 36 Composition Textbooks (0%)	6 of 24 Science-writing textbooks (25%)
- - - - - - - - - - - - - -	"One rule that always applies is that the figures and tables must 'stand alone.' Another way of saying this is that a reader should not have to refer to the text to figure out what a figure or table shows or what it means." (Matthews & Matthews, 2014, p. 65)

A noteworthy observation is that it seems science students are being told both that visuals must stand alone—that the data in the visual should be understood without written explanation—but also that the writer must refer to the visuals in the text—that "the reader should be told their significance, why they are there and what they show, and this needs to be done at certain points in the narrative, and in certain ways" (Montgomery, 2017, p. 189). As a result, there might be confusion as these students try to discuss the visuals in their written text. Explicit explanation regarding these seemingly contrasting comments might help science students better comprehend composing conventions for integrating visuals—especially since it is a theme not covered in composition textbooks.

4. Visual design and creation

A key element of the instruction of visual communication in the textbooks is helping guide students when creating visual elements in their documents. As mentioned previously, both disciplines' textbooks present document design elements as integral to creating clear, useful content, such as choices in color, fonts, labeling, and headings. In addition, Table 7 shows how the textbooks offer practical advice on constructing all sorts of visual elements, from document design to data displays. Science-writing textbooks provide specific steps for illustrating quantitative data while sometimes offering details that concentrate on readability of visuals, and the composition textbooks only describe the latter.

Table 7: Visual design and creation: Tips for creating and/or designing visuals

20 of 36 Composition Textbooks (55.5%)	17 of 24 Science-writing textbooks (70.8%)
"Omit lines around cells in a table; use them only to set off headings or to indicate major divisions….Leave space between columns, and align numbers to make graphics easier to read. Avoid using special views or shading that could make your visual more difficult to interpret." (Howard, p. 84)	"Do not place too much information in one figure—it will appear too packed. Do not leave too much white space either—the graph will appear not well-constructed….Three or four curves should be the maximum in a line graph, especially if the lines cross each other two or more times. When curves must cross, use lines of different thickness or patterns…" (Hofmann, 2016, p. 84)

Strikingly, a significant number of composition textbooks provide one final discussion of creating visuals: visual composition assignments. Students are invited to complete activities or assignments in which they create their own visual document, such as a photo-essay, a brochure, a collage, a poster, or a map of a problem or issue. As illustrated in Table 8, these activities are often designed to give students practice reflecting on their composing processes, understanding genres by remixing a written text into a visual one, and helping them build their ethos as writers, all typical outcomes of composition classes. For these reasons, it is not surprising that the science-writing textbooks do not include such activities, but instead emphasize the steps for creating and designing images that display scientific data.

Table 8: Visual design and creation: Visual composition assignments

11 of 36 Composition Textbooks (30.5%)	0 of 24 Science-writing textbooks (0%)
"Now that you've written an essay that challenges a conventional way of thinking, combine several images…to create a visual essay that challenges common thinking….In several paragraphs, explain how the different images of your collage combine to put forth a unified main claim about the topic." (Mauk & Metz, 2019, pp. 424-5)	- - - - - - - - - - - - - -

5. Writers might start with visuals

When working with visuals, both science-writing textbooks and composition textbooks indicate that writers might create visuals as the first step in the writing process. Table 9 demonstrates the first of two discrete conventions covered in the textbooks: That writers sometimes visually organize their ideas to see how they might all fit together in a paper. "Concept maps," "clustering," "mind maps," "storyboards," "visual diagram," and "process flowchart" are all terms used by the textbooks to describe these activities. These visuals are often created prior to any composing of the final document, and possibly prior to any research since such brainstorming techniques can be used to select or narrow the theme to be discussed in a paper. As invention/prewriting activities, these visuals are not necessarily designed with the expectation that they will go into the final paper; instead, they are grouped with activities like research notes, outlines, and rough drafts—steps that help the writer get to a finished product but that are not shown to others.

Table 9: Writers might start with visuals: Visually organizing ideas to map the paper

19 of 36 Composition Textbooks (52.8%)	5 of 24 Science-writing textbooks (20.8%)
"Clustering (sometimes called 'mapping') is a more visual version of brainstorming. You write the main idea or keyword in the middle of a blank page. Then you generate associations that you circle and connect with straight lines to create a grid of ideas." (Saba, 2017, p. 82)	Mind maps "provide a good starting point," "help you to organise a large quantity of information," "can be expanded to a greater level of detail," and "can be easily modified as the project evolves" (Aliotta, 2018, pp. 43-4)

Meanwhile, science-writing textbooks indicate that starting the writing process with visuals can be a way of identifying key results, thus helping make the task of writing more efficient as illustrated in

Table 10. While two composition textbooks do include information on this topic, both are WAC/WID-focused composition textbooks that cover writing in science disciplines.

Table 10: Writers might start with visuals: Using visuals to identify key results

2 of 36 Composition Textbooks (5.5%)	8 of 24 Science-writing textbooks (33.3%)
"The very first step in writing a paper doesn't involve writing at all. A scientist first designs a study to answer a specific research question; the study then yields data, and the scientists constructs a figure—typically a table or graph—to make the data easy to see and understand." (Ward & Vander Lei, 2012, p. 260)	"In the process of conducting research, scientists often begin to construct rough tables to consolidate or summarize relevant information….As early as is feasible, begin to organize your data into tables in various formats. By consolidating or summarizing information, the process will help you write your first draft more efficiently. Tabular format invites comparisons that would be lost or incomprehensible in narrative form." (Matthews & Matthews, 2014, p. 83)

Comparing the textbooks that discuss starting with visuals illustrate that scientists tend to view invention as occurring through the practice of science research. In other words, visuals can act as a vehicle for understanding what the data say or reveal, and for conveying information; thus, they may be essential components to the finalized document. In fact, starting with visuals is so important to writing in the natural sciences that Gastel & Day (2016) note, "To construct [figures and tables] after drafting the paper is as if an architect were to build a house before drawing the plan" (p. 22). Meanwhile, the composition textbooks emphasize giving students visual invention tools that aid their thinking and learning across composing situations, but that are not designed with the purpose of being included in the finished document. Since several science-writing textbook authors did include this advice, there is value in science writers using such visual tools for learning, thinking, and planning.

6. Ethical use of visuals

Tables 11 and 12 indicate the two distinct ways in which the science-writing and composition textbooks discussed ethical issues of visual use and design: avoiding the misrepresentation of data and adhering to copyright and citation guidelines. As observed with previous themes, the composition textbooks include general reminder statements to use visuals ethically and avoid misleading visuals. The science-writing textbooks also offer recommendations to take care when creating visuals, but highlight the need for accurate data, typically using harsher tones when discussing a writer falsifying data, whether intentionally or not.

Table 11: Ethical use of visuals: To avoid misrepresenting data

11 of 36 Composition Textbooks (30.5%)	3 of 24 Science-writing textbooks (12.5%)
"If you alter a visual or media file, be sure to do so ethically….Never mislead readers. Show things as accurately as possible." (Lunsford, 2017, p. 36)	"Falsifying data is, perhaps even more than plagiarism, an unforgivable offense, and one that can get you into serious trouble. Biologists build on the work of others, and that involves a lot of trust." (Pechenik, 2016, p. 168)

As mentioned previously, both creation of one's own visual and integration of others' visuals are included in composition textbooks because they are used in courses designed to introduce students from a wide variety of majors to general academic composing processes. Meanwhile, the findings

signify that scientific figures are more likely to be created by the writer than copied from elsewhere because the data—the results of the scientist's research—are in the visuals. Thus, it is not surprising that so few science-writing textbooks incorporate copyright and citation information. What is surprising, however, is that so few science-writing textbooks speak to the significance of the misrepresentation of visual data since students would be learning the most appropriate ways of presenting that information. Perhaps such discussions did appear in the examined textbooks, but did so in sections that did not cover visuals or were made implicitly within the instructions for designing good visuals.

Table 12: Ethical use of visuals: Issues of copyright and citation

17 of 36 Composition Textbooks (47.2%)	1 of 24 Science-writing textbooks (4.2%)
"The last step in using images or audiovisual materials is to give credit to their creators and, if necessary, acquire permission to use them." (Glenn, 2018, p. 303)	"We consider the tangible expressions of an author to be his or her own intellectual property and must ask permission for or acknowledge use of it. This intellectual property may exist as the words describing a concept or other media such as data in tables and figures…" (Davis, Davis, & Dunagan, 2012, p. 239)

7. Analysis of visuals

The act of analyzing visuals in academic writing is important for both writers and readers. Table 13 illustrates how the textbooks provide instruction for analyzing visuals. Because composition courses are designed to broadly teach students how to negotiate various writing practices across the conventions of multiple writing contexts, the composition textbooks offer more insight than the science-writing textbooks into the rhetorical analysis of visuals. Composition textbook writers perceive their readers to not have built-in assumptions about the importance of communication, so they provide rationales. Two justifications for having students do rhetorical analyses are offered: to help them be better consumers of popular or cultural texts and to learn how to make their own meaningful rhetorical decisions when creating or using visuals in future communication projects. Many textbooks offer Gestalt principles and visual design models centered on contrast, alignment, repetition, and proximity to guide students' visual rhetorical analyses; however, some of the textbooks' heuristics only mention elements such as author's purpose, audience, organization, and genre. Employing what are essentially repurposed textual analysis categories illustrates a missed opportunity in those textbooks for students to develop relevant tools for viewing visuals.

Table 13: Analysis of visuals

24 of 36 Composition Textbooks (66.7%)	6 of 24 Science-writing textbooks (25%)
"We want our students to always be aware of how writing and designing work together….Both design and content influence how audiences respond to a text's message, so developing familiarity with design concepts and practices as well as textual and rhetorical composition is critical for successful communication" (Ball, Sheppard & Arola, 2018, p. v)	"As with writing, you can learn a lot about producing good graphics by studying the admirable work done by others—and the opposite. Not only will this provide you with guiding examples to emulate and avoid, it will also help sharpen your critical faculty about what goes into such an image, what makes it effective, easily deciphered, informative, attractive." (Montgomery, 2017, p. 169)

The science-writing textbooks offer instruction reminiscent of this rhetorical decision-making, but none of the science-writing textbooks use that language to describe the analysis. Instead they assume that readers understand the need for strong, clear communication and emphasize the skills necessary for an individual to effectively communicate information during their project. Perhaps because their readers are usually more advanced than those of composition textbooks, the science-writing textbooks spend less time giving foundational instruction on how to analyze visuals, assuming that information has been taught previously. Additionally, since science-writing textbooks have the goal of teaching students to communicate within the boundaries of scientific conventions, it is sensible for them to identify how the act of analysis can improve their composing strategies within this finite context.

8. Reading visuals

While many of the previous themes highlight how visuals are important for the writer during the writing process, the act of readers reading visuals is also significant. Both composition and science-writing textbooks focus on teaching students how to read visuals in order to understand "*what* it says and *how* it communicates it *[sic]* purpose and reaches its audience" (Hacker & Sommers, 2016, p. 83). In order to comprehend the *what*, both disciplines' texts provide steps for reading visuals, depicted in Table 14.

To examine the how, the composition textbooks recommend reading rhetorically in order to identify the meaning, context, and purpose of each visual. Thus, the goals are to help students learn how to read visual information and to consider the rhetorical decisions that impact the effectiveness of the message, which directly link to the fact that composition courses emphasize rhetorical analysis. Meanwhile, the science-writing textbooks examine how scientists do not read from the first to last word, but jump from most to least important or interesting section. Knowing that scientists actually prioritize reading visuals can impact students' abilities to adapt their reading processes to match the discipline's conventions, as well as their choices when writing to those readers.

Table 14: Reading visuals: Considering what and how to read

8 of 36 Composition Textbooks (22.2%)	5 of 24 Science-writing textbooks (20.8%)
What to read "Read the title or heading," "Read any notes, description, and the source information at the bottom of the graphic," "Study the labels," "Study the information," and "Draw conclusions" (Seyler & Brizee, 2019, p. 125)	What to read "Look at each figure and read the figure caption to determine what kind of results were collected." (Knisely, 2017, p. 37)
How to read "Preview the visual….study the visual as a whole….and then examine its parts, read the caption and any accompanying text, consider the context, and make connections….determine the author's purpose and intended message" (McWhorter, 2018, p. 73)	How to read "After the abstract and conclusions, people look at images—pictures, schematics, charts, histograms, graphs—then tables, and finally text" (Patience, Boffito & Patience, 2015, p. 67)

One additional act of reading, displayed in Table 15, is how visual activities can be applied when reading a text. Such tools as mind maps and clustering help readers read actively, fully understand a text, and track their notes for research projects. Only a small number of textbooks from both disciplines incorporate mapping as a reading activity even though most of the textbooks discuss how vital a skill reading is in composition and the sciences. Perhaps both disciplines consider critical reading a skill that students learn prior to the courses that make use of these textbooks; however, the textbooks that do include this content claim how much understanding reading conventions impacts students' abilities to successfully become a member of the discipline as both a reader and a writer. As such, perhaps more textbooks will soon join this trend.

Table 15: Reading visuals: How visual activities aid the reading of a text

4 of 36 Composition Textbooks (11.1%)	2 of 24 Science-writing textbooks (8.3%)
"Drawing a map of a text can help you to identify key points and understand the relationships among ideas in a reading." (Faigley, 2016, p. 22)	"Mind maps are a way for readers to organize knowledge about a topic visually. Mind mapping is based on the premise that new knowledge must be integrated with existing knowledge before further learning is possible. Without this integration, new knowledge is quickly forgotten and misconceptions in existing knowledge will continue." (Knisely, 2017, p. 41)

Conclusions

The results of the textbook analysis presented here show that both composition and natural science-writing textbooks discuss many of the same themes but often address them differently. These distinctions seem based on the goals of the classes themselves, the roles visuals play within the disciplines' writing and researching conventions, and the identified audiences for the textbooks. For instance, the aims of composition classes are often process-oriented: The WPA Outcomes Statement

for First-Year Composition (2014) claims that first-year students should learn to analyze situations and audiences, be authoritative and make assertions, develop useful composing processes, and consider a variety of genres and methods of communicating. Thus, even though composition scholarship covers a broad range of visuals, the ways visuals are covered in composition classrooms and textbooks are limited by the outcomes of the classes themselves: visuals tend to be used as a tool for learning and organizing ideas, trying out new genres or media, or as an artifact to be read or analyzed. Meanwhile, because all summary and synthesis of literature is relevant for all disciplines, composition classes typically contain research writing units that center on discursive rather than visual evidence (e.g.: quotes from scholarly articles). And because students are learning foundational skills, visuals used often do not depict data discovered by the student researcher; rather, they may be replicated from elsewhere and cited.

Meanwhile, the goal of science classes is to teach often upper-level students the best practices of doing science; learning to communicate in the sciences is not separated from the context of researching and experimenting, and visuals often fall heavily within these practices. While science writers do employ visual learning and organizing tools, the act of creating a visual is part of the scientist's process of organizing and understanding data, so rarely will a replication of another's visual be used. Also, science research concentrates on quantitative data that are most efficiently presented in visual form or that depict features of habitats, species, etc. that must been seen in order to be comprehended. Thus, it is evident that the science textbooks' discussions of visuals are linked to disciplinary conventions and traditional pedagogical practices.

It should be mentioned briefly that the textual analysis methods used here for analyzing these textbooks are limited in that they do not take into consideration other classroom factors. In particular, this examination does not consider how individual instructors to select, modify, and supplement the textbooks' content based on what they and their institutional program consider important to teach. In addition, examining only certain segments of the textbooks based on locating key terms misses some of the nuance of the authors' design and scaffolding of materials through chapters, units, and the textbooks as a whole. This decontextualization might oversimplify the holistic purposes and goals set by the textbook authors. And by examining only selected pages and sections, this research might also miss some of the explicit rationale being provided about a discipline's communication conventions as a whole.

However, what this focused textbook examination does offer is access to some distinctive methods for using visuals and teaching visual communication, which might be further probed by writing instructors and instructors in the sciences to help students better understand disciplinary conventions and transfer learning. For instance, Bohr and Rhoades (2014) argue that instructors' "disparate ways of talking about writing instruction prevented students from making connections." Thus, composition instructors might ask students to consider why "visual analysis" and "visual rhetoric" are terms used more by composition than science textbooks. Discussions could then identify why visual rhetorical analysis is an outcome of a composition class and important to the students' overall learning. Projects that invite students to examine how visual communication terms are used in their textbooks, perhaps tracking different uses in other classes, could act as a starting point for identifying the writing, researching, thinking, and learning processes, including how visuals are used for each of these, within the course and discipline.

Similar examinations of textbooks could be utilized in WAC/WID classes. Classroom discussions and tasks could center on rhetorically understanding the purposes for differing conventions to then help students consciously build bridges for transferring visual communication knowledge across disciplines. In doing so, instructors focus on teaching concepts more than discreet skills, challenging students to learn how to think about writing. Activities could be informal and brief; for example, in groups, students could be asked to identify disciplinary values by comparing/contrasting the ways certain visual communication terms appear and are defined in composition textbooks versus in the

natural sciences or other science fields. Or students could reflect on the written and visual communication skills they have practiced and learned previously and make assumptions about future composing contexts in order to consider what skills and learning might be transferred from one class to another.

Likewise, formal research projects could ask students for in-depth analyses of the written and visual communication terms and themes found in two or more disciplines' textbooks, to interview other students and professors in the sciences, and/or to examine class assignments in both the sciences and composition. These types of investigations would likely heighten students' awareness of the visual communication terms, conventions, and composing practices in composition but also in another discipline. These activities would allow WAC/WID instructors to gauge students' expertise and assumptions while providing opportunities to identify possible discipline-specific practices without expecting instructors to know every nuance of composing conventions in multiple disciplines or to teach students how to compose in another discipline. Students perform these investigations in order to be more conscious of their composing processes and be better prepared to adapt those processes when they come upon new rhetorical contexts. And, these types of activities could be broadened to examine a wider variety of disciplinary or generic expectations and practices.

This research also calls for authors of textbooks to pay closer attention to visual communication practices and how they might be specific to their discipline or might meet expectations more universally. In particular, WAC/WID textbooks that examine disciplinary conventions and practices should include more in-depth discussions of visuals. Many of the WAC/WID textbooks and handbooks examined here, even ones with sections dedicated to scientific writing, offer little, if any, discussion of visual communication in relation to writing and research beyond document design topics. This indicates the general trend of WAC/WID instruction focusing primarily on written communication. But because textbooks that examine disciplinary conventions are meant to address key components of the writing processes of members of each discipline, visual communication should be included.

WAC/WID textbook authors might descibe details about the reading and/or composing processes of scientists, perhaps including brief interviews with scholars from different disciplines to share their own observations and practices. They also might draw in more writing studies scholarship on visuals that offer frameworks for visual rhetorical analysis activities, such as Kostelnick's (1996) supra textual design, consisting of textual, spatial, and graphic modes, or Hullman and Diakoplous's (2011) visualization rhetoric framework that breaks down the elements of visuals into data, visual representation, annotation, and interactivity. Offering instructors pedagogical rationales and curricular applications to help students work with visual quantitative data, like those suggested by Sorapure (2010), and support for instructors' assessment of visual assignments, discussed by scholars such as Odell and Katz (2009) and McKee and DeVoss (2012), could also add depth to currently provided visual activities. And, more broadly, just as changes in technology are impacting the scholarship in the sciences and in writing studies, such as The Optical Society's Interactive Science Publishing, which allows for interactive 2D and 3D visual scientific data, or *Kairos: A Journal of Rhetoric, Technology and Pedagogy* and the Computers and Composition Digital Press, which present highly visual research in digital, multimodal, and new media forms, authors might likewise reenvision electronic textbooks as more than "largely-static replicas of print counterparts" (Bikowski & Casal, 2018, p. 120).

Thus, the analysis in this article of the common themes and terms in composition and science-writing textbooks helps provide understanding of these disciplines' practices and conventions of visual communication. Specifically, bringing to light these distinctions can help composition instructors recognize how what they teach are influenced by conventions of the composition discipline, that they are not always conveying "genres-in-general" (Wardle, 2009, p. 769) or "universal skills" (Wolfe,

Olson, & Wilder, 2014, p. 43). This knowledge can then adapt WAC/WID classroom instruction to more clearly articulate to students the purposes of composition classes and conventions of the discipline in order to be prepared to consider the conventions of various composing situations and better apply those rhetorical skills in other contexts. And for composition and science instructors, revising the approach to teaching visual communication might be beneficial for aiding students' awareness of the composing and reading processes used in various disciplines, helping them to transfer their knowledge from composition courses into science-writing contexts, and perhaps beyond.

Appendix A: Composition Textbooks Examined

Title	Authors	Year	Publisher
A Writer's Reference with Writing in the Disciplines	Diana Hacker, Nancy Sommers	2016	Bedford/St. Martin's
An Insider's Guide to Academic Writing	Susan Miller-Cochran, Roy Stamper, Stacey Cochran	2018	Bedford/St. Martin's
EasyWriter with Exercises	Andrea Lunsford	2017	Bedford/St. Martin's
Everything's an Argument	Andrea A. Lunsford, John J. Ruszkiewicz	2019	Bedford/St Martin's
From Critical Thinking to Argument	Sylvan Barnet, Hugo Bedau, John O'Hara	2017	Bedford/St. Martin's
Successful College Writing	Kathleen T. McWhorter	2018	Bedford/St. Martin's
The Academic Writer: A Brief Rhetoric	Lisa Ede	2017	Bedford/St. Martin's
The Bedford Researcher	Mike Palmquist	2018	Bedford/St. Martin's
Writer/Designer	Cheryl E. Ball, Jennifer Sheppard, Kristin L. Arola	2018	Bedford/St. Martin's
Academic Writing, Real World Topics	Michael Rectenwald, Lisa Carl	2016	Broadview
Focus on Writing: What College Students Want to Know	Laurie McMillan	2019	Broadview
The Broadview Guide to Writing: A Handbook for Students	Corey Frost, Karen Weingarten, Doug Babington, Don LePan, Maureen Okun	2017	Broadview
The World is a Text: Writing About Visual and Popular Culture	Jonathan Silverman, Dean Rader	2018	Broadview
Becoming Rhetorical: Analyzing and Composing in a Multimedia World	Jodie Nicotra	2018	Cengage
Composing to Communicate: A Student's Guide	Robert Saba	2017	Cengage
Harbrace Essentials with Resources Writing in the Disciplines	Cheryl Glenn, Loretta Gray	2018	Cengage
Keys for Writers	Ann Raimes, Susan Miller-Cochran	2018	Cengage
Perspectives on Contemporary Issues: Reading across the Disciplines	Katherine Ackley	2018	Cengage

The College Writer: A Guide to Thinking, Writing, and Researching	John Van Rys, Verne Meyer, Randall VanderMey, Pat Sebranek	2018	Cengage
The Composition of Everyday Life	John Mauk & John Metz	2019	Cengage
The New Harbrace Guide: Genres for Composing	Cheryl Glenn	2018	Cengage
The Well-Crafted Argument: Across the Curriculum	Fred D. White, Simone J. Billings	2016	Cengage
Writing Analytically	David Rosenwasser, Jill Stephen	2019	Cengage
The Digital Writer	Sean Morey	2017	Fountainhead
Writing Moves: Composing in a Digital World	Eleanor Kutz, Denise Paster, and Christian Pulver	2018	Fountainhead
A Writer's Resource	Elaine Maimon, Janice Peritz, Kathleen Blake Yancey	2016	McGraw-Hill
Read, Reason, Write	Dorothy U. Seyler, Allen Brizee	2019	McGraw-Hill
The McGraw-Hill Guide: Writing for College, Writing for Life	Duane Roen, Gregory Glau, Barry Maid	2018	McGraw-Hill
Writing Matters: A Handbook for Writing and Research	Rebecca Moore Howard	2018	McGraw-Hill
Norton Field Guide	Richard Bullock, Maureen Daly Goggin, Francine Weinberg	2016	Norton
Backpack Writing	Lester Faigley	2016	Pearson
Compose, Design, Advocate	Anne Frances Wysocki, Dennis A. Lynch	2018	Pearson
Real Texts: Reading and Writing Across the Disciplines	Dean Ward	2012	Pearson
Student's Book of College English	David Skwire, Harvey Weiner	2016	Pearson
Writing in the Disciplines: A Reader and Rhetoric Academic for Writers	Mary Lynch Kennedy, William J. Kennedy	2012	Pearson
Rhetoric in Civic Life	Catherine Helen Palczewski, Richard Ice, John Fritch	2016	Strata Publishing, Inc

Appendix B: Science-writing Textbooks and Handbooks Examined

Title	Authors	Year	Publisher
Communicate Science Papers, Presentations, and Posters Effectively	Gregory S. Patience, Daria C. Boffito, Paul A. Patience	2015	Academic Press
Medical and Scientific Publishing	Jasna Markovac, Molly Kleinman, Michael Englesbe	2018	Academic Press
Scientific Papers and Presentations: Navigating Scientific Communication in Today's World	Martha Davis, Kaaron Davis, Marion Dunagan	2012	Academic Press
Writing Papers in the Biological Sciences	Victorian E. McMillan	2017	Bedford/St. Martin's

How to Write and Illustrate a Scientific Paper	Bjorn Gustavii	2017	Cambridge University Press
Successful Scientific Writing: A Step-by-step Guide for the Biological and Medical Sciences	Janice R. Matthews, Robert W. Matthews	2014	Cambridge University Press
Writing in the Environmental Sciences: A Seven-Step Guide	L. Michelle Baker	2017	Cambridge University Press
Writing Undergraduate Lab Reports: A Guide for Students	Christopher S. Lobban, Maria Schefter	2017	Cambridge University Press
Mastering Academic Writing in the Sciences: A Step-by-step Guide	Marialuisa Aliotta	2018	CRC Press
How to Write and Present Technical Information	Charles H. Sides	2017	Greenwood
How to Write and Publish a Scientific Paper	Barbara Gastel, Robert A. Day	2016	Greenwood
Reading and Writing Knowledge in Scientific Communities	Gérald Kembellec, Evelyne Broudoux	2017	ISTE
A Concise Guide to Communication in Science and Engineering	David H. Foster	2017	Oxford University Press
Writing in the Biological Sciences: A Comprehensive Resource for Scientific Communication	Angelika H. Hofmann	2016	Oxford University Press
Writing for Science Students	Jennifer Boyle, Scott Ramsay	2017	Palgrave
Short Guide to Writing about Biology	Jan A. Pechenik	2016	Pearson
Crafting Scholarship in the Behavioral and Social Sciences: Writing, Reviewing, and Editing	Robert M. Milardo	2015	Routledge
A Student Handbook for Writing in Biology	Karin Knisely	2017	Sinauer Associates, Inc
Introduction to Scientific Publishing	Andreas Öchsner	2013	Springer
The Craft of Scientific Writing	Michael Alley	2018	Springer
Composing Science: A Facilitator's Guide to Writing in the Science Classroom	Leslie Atkins Elliott, Kim Jaxon, Irene Salter	2017	Teachers College Press
The Chicago Guide to Communicating Science	Scott L. Montgomery	2017	University of Chicago Press
Writing Scientific Research Articles: Strategies and Steps	Margaret Cargill, Patrick O'Connor	2013	Wiley-Blackwell
Listen, Write, Present: The Elements for Communicating Science and Technology	Stephanie Roberson Barnard, Deborah St James	2012	Yale University Press

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