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Don't Forget the Pictures: Using Graphical Devices to Learn about Space

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Abstract

This exploratory study investigates whether and how teaching students to read and understand the graphics in science texts improves their understanding of the graphical devices and the science content. Based on pre-/post-assessment analysis, students' understanding of diagrams, cross-sectional diagrams, tables, overall graphical device knowledge, and content knowledge of outer space significantly increased. The article also includes recommended lessons and books with exemplar graphical devices to utilize in instruction.

"I cannot find the answer!" Nancy often heard this statement from students in her fourth grade classroom. "Try going back into the reading passage," she commonly replied. "I did, the answer is not there!" the students would continue. Many times the students would overlook the graphical devices on the page, which could have helped them understand the information and answer the questions.

Fast forward to June: "Ms. B! Ms. B! Look what I found." Logan (all names are pseudonyms) ran up to show Meghan, a volunteer and researcher in the classroom, the graphical device she found. Excitedly pointing to the diagram of a typical royal palace, she continued, "Right here on page twenty-four. This is *exactly* what you've been teaching us about, and I found it in my independent reading book, *Who Was King Tut?* (Edwards, 2006)."

With each subsequent visit, as Meghan walked into the classroom, students could not contain their excitement about the graphical devices they had discovered in their independent reading during the week. For example, Collin, who was reading *Al Capone Does My Shirts* (Choldenko, 2004), pointed out a diagram of Alcatraz in the beginning of the book: "As I am reading the chapters, I go back to the diagram to see where each part of the story is located on the diagram." Suzie found a flowchart in her book, *Doodle Bug: A Novel in Doodles* (Romano Young, 2010): "Look Ms. B! There's a flowchart showing the steps to open an envelope and read a letter."

Much of this change began when Nancy and Meghan initiated an interdisciplinary unit on space with an emphasis on graphics (illustrations and photographs with and without illustration extensions, such as captions and labels) near the end of the school year. The unit highlighted five specific graphical devices including captioned pictures, surface diagrams, cross-sectional diagrams, flowcharts, and tables. Nancy, who had taught this unit many times before, saw her students increase their engagement in and enthusiasm for both the graphical devices and the topics of the texts they were reading. As the comments above demonstrate, the students were no longer ignoring the graphics found in the books they were reading; they were using them to learn.

Theoretical Framework

This study is grounded in the belief that being literate extends beyond the ability to read and write words and encompasses the ability to think about, create, and communicate meaning from spoken, written, and visual text (e.g., IRA/NCTE, 1996; The New London Group, 1996). After all, graphics are often considered a language of their own (Avgerinou & Ericson, 1997), and in today's world, the ability to decode and interpret these graphics is becoming more important (e.g., Lancaster & Rowe, 2009; Oblinger & Oblinger, 2005). Additionally, we believe that comprehension is a non-unitary construct (Duke & Roberts, 2010) and that we process different written genres (e.g., Kucan & Beck, 1996) and graphical devices (Norman & Roberts, 2015) differently. Therefore, just as we need to teach children to read and comprehend different written genres, we must teach them to read and comprehend different graphical devices in order to better understand the text as a whole.

Graphics in Children's Informational Text

Teaching students about graphical devices is important because graphics are prominent in children's books (e.g., Carney & Levin, 2002), especially informational texts (e.g., Fingeret, 2012; Purcell-Gates, Duke, & Martineau, 2007), and often convey information not found in the written text (e.g., Fingeret, 2012; Moss, 2008). Furthermore, recent research found that graphical device comprehension accounts for 15.4% of overall comprehension when reading informational texts (Roberts, Norman, & Cocco, 2015).

Research suggests that when reading books with pictures, readers' attention is drawn to the pictures (e.g., Holmqvist & Wartenberg, 2005), especially when the graphics are explicitly referenced in the text (e.g., Varhallen & Bus, 2011), but not all readers utilize the graphics in effective ways that actually support comprehension. Some studies (e.g., Hannus & Hyona, 1999) have found that students classified as "good readers" benefit more from the inclusion of graphics, perhaps because they are better able to integrate the information presented in the graphics with the written text. Other researchers (e.g., Rusted & Coltheart, 1979) have found that those classified as "poor readers" benefit more from the inclusion of graphics, perhaps because it gives them another avenue by which to comprehend the information. Regardless of who benefits more from graphics, the ability to use graphical devices follows a developmental path, and children in third grade and beyond are still working toward more sophisticated understandings of most graphical devices (Duke, Roberts, Norman, 2011).

Graphics and Common Core

Within many states and schools there is a push to adhere to the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The standards emphasize informational text as well as the use, production, and understanding of graphical devices. In fact, there is at least one standard at each grade level that addresses graphical devices. Please see Table 1 for selected Common Core State Standards. We believe these shifts are beneficial for children, especially given their natural curiosity about the world around them. Young readers may find informational texts motivating because they offer answers to many questions and because they often contain graphics that provide another means by which readers can comprehend and learn the content. Our unit of study was based on graphics within science class, specifically using space as a theme.

Table 1

Common Core Standards Associated with Graphical Devices

College and Career Readiness Anchor Standards for Reading: Students must demonstrate an ability to respond to literature by employing knowledge of literacy, language, graphical devices, and forms to read, comprehend, reflect upon, and interpret literary text from a variety of genres and a wide spectrum of American and world cultures.	
Kindergarten	Name the author and illustrator of a text and define the role of each in presenting the ideas or information in a text. (Reading Standard 6)
Grade 1	Distinguish between information provided by pictures or other illustrations and information provided by the words in a text. (Reading Standard 6)
Grade2	Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text. (Reading Standard 7)
Grade 3	Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. (Speaking & Listening Standard 2)
Grade 4	Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, timelines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (Reading Standard 7)
Grade 5	Write informative/explanatory texts to examine a topic and convey ideas and include formatting [e.g., headings], illustrations, and multimedia when useful to aiding comprehension. (Writing Standard 2)

Project Overview and Background

We believed that graphics can convey crucial information, but we observed that students did not always understand how to garner this information from them. As a result, we wanted to support fourth grade students as they learned to "interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, timelines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears" (Reading Standard 7).We thus designed this exploratory study to determine whether and how teaching students to use the graphics in science texts would improve their understanding of the graphical devices and of the science content. Recognizing that informational texts intrinsically motivated our students, we believed that learning to understand graphical devices would help drive their ability to gain information from these texts. We also believed that integrating the study of graphics and science would improve the students' literacy and science understandings.

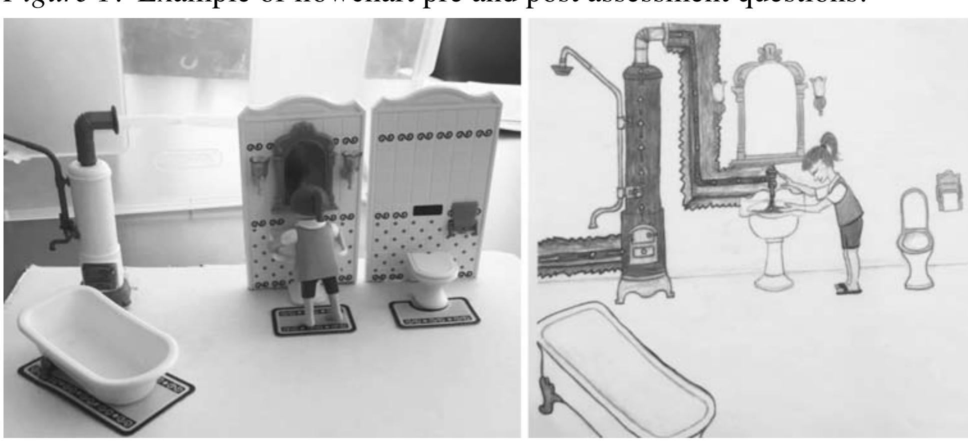
Method

Participants and Measures

Although all twenty-seven students in Nancy's fourth grade class in an urban parochial school in New York State participated in the instruction, we pre- and post- tested the 15 fourth graders (10 girls and 5 boys) for whom we received parental permission. Demographic information was not available for the fourth-grade class, but the school demographics included 10% Asian, 13% African American, 17% Hispanic/Latino, and 60% Caucasian students. For the class as a whole, about 33% of the students read below grade-level, 45% read on grade-level, and 22% read above grade-level based on their guided reading assessments.

We assessed each student individually on their understanding and use of surface diagrams, cross-sectional diagrams, captions, tables, and flowcharts using the Graphical Device Comprehension Assessment (Duke, Roberts, & Norman, 2011). For each of these five graphical devices, students answered questions that assessed their ability to name the device, select an example of the device, explain what the device showed, and use the device to gain information. Please see Figure 1 for an example assessment question about a flowchart.

Figure 1. Example of flowchart pre and post assessment questions.



SAY: **This picture shows how water is heated up and then gets to your sink. Using these toys** [point] **can you show what the picture shows?** (Hand bathroom to child with bathtub closest to the child)

For captions, they were also asked to generate a caption to accompany a picture. Each question received a score of 0-2 points (0- incorrect, 1- partially correct, 2- correct). We calculated a composite score for each graphical device by dividing the total number of points a student earned by the total number of possible points and multiplying by 100. Finally, we assessed students' pre- and post-knowledge of outer space using a teacher-designed test that included questions about both outer space and the graphical devices. For the graphical device questions, students were asked to create examples of the five graphical devices. Each created graphical device was scored using a 0-2-point scale (0- incorrect/unscorable, 1- partially correct, 2- correct). Please see Figure 2 for the criteria used to score each graphical device.

Analysis

Once we determined the scores, we inputted the data into SPSS for statistical analysis. We ran a repeated measure t-test to compare the students' pre- and post-assessment scores. For this test, a negative T-value indicates that the students showed growth from pre- to post-assessment. The lower the score, the more growth was made. Finally, if the p value for these t-tests was less than .01, the differences were significant. For the graphical device scores on the teacher created assessment, we examined students' scores on the individual devices to determine if they demonstrated *full mastery* (all 2s), *partial mastery* (combination of 2s, 1s, and 0s), or *did not demonstrate mastery* (mostly 0s) of the graphical devices. We then tallied the number of students in each category for each graphical device.

Figure 2. Criteria used to assess students generated graphical devices (adapted from Roberts, Bruger, & Norman, 2014).

Captioned Images ____ Words describe, comment on, or provide additional information about the image ____ Uses sentence(s) or descriptive phrase (i.e., not a label) ____ Vocabulary is likely accessible to students	**Surface Diagrams** ____ Clearly illustrates surface of object ____ Specific, individual parts are labeled (with or without additional description) ____ Lines are used to connect labels to image
Flowcharts ____ Images are sequenced to depict stages of a process (with or without words) ____ Direction of action is apparent through use of arrows, lines, or order of images	**Cross-Sectional Diagrams** ____ Clearly illustrates interior of object ____ Specific, individual parts are labeled (with or without additional description) ____ Lines are used to connect labels to image
Table ____ Organized in rows and columns ____ Includes numbers and shorts (not sentences) ____ Includes headings ____ Information in table not redundant with headings	

The Lessons

In order to help students understand both the graphical devices and the science content, Meghan and Nancy created integrated lessons addressing both. The lessons, described below, were designed to be interactive and to include at least one graphical device per lesson. Before having the students use the graphical devices in practice, we presented each device by providing direct instruction about its definition and uses. The information contained in each of the graphics we used pertained to outer space, ensuring that even when teaching a lesson on a device, the students were also learning science content. The initial lessons always included a student-friendly definition of the device (see Figure 3) and a model of how to interpret each device. The students would then take part in an activity on the interactive whiteboard where they would have to drag and drop the different parts to complete the graphical device. Throughout all of the lessons, when the graphical devices were presented, we would review the definition and use of the graphical device again to ensure understanding. To end each lesson on a graphical device, the students would go on a graphical device hunt within other science texts within the classroom library. Again we used our resources to ensure that these texts matched the content being taught in order to increase exposure to the material. These graphical device hunts were also used as assessments to determine if students had an understanding of each graphical device.

In order for the students to gain more understanding, we taught lessons in which the students had to decode and use the graphical devices. We also encouraged students to answer questions based on the devices. Students compared the information presented in a reading to the information presented in a graphical device and discussed how to use both to enhance learning. Finally, we challenged the students not only to learn how to read the graphical devices but also to create their own. Overall, we created many different learning experiences that incorporated the graphical devices so students would have many, varied exposures.

We introduced one graphical device each week so as not to overwhelm the students. Because this unit spanned an eight-week period, we were limited in our time frame. Also, we only presented them to the students using one content area. These graphical devices, however, are found in books related to all content areas, so teachers are not limited as to how or when they can teach about graphics.

Figure 3. Student-friendly definitions of the graphical devices.

Captions	A complete sentence or descriptive phrase near a picture that explains the picture.
Diagrams	A picture that shows its parts and has label.
Cross Sectional	A picture that shows the inside parts and has labels.
Tables	Information organized in columns and rows.
Flowcharts	Stages of a process connected by lines or arrows in order.

Results

We hypothesized that integrating instruction on graphical devices into a unit on space would improve both the students' literacy and science understandings. The results indicate that both areas of students' learning increased. As Table 2 demonstrates, there was a statistically significant increase in the students' understanding of most of the graphical devices. On the pre-test for overall understanding of graphical devices, students' scores ranged from 13.75 to 75.92 (M=66.99, SD=5.88), while on the post-test, their scores ranged from 68.33 to 96.25 (M=82.83, SD=8.24). A pre-post analysis indicated that the increase in understanding of graphical devices was statistically significant (T=-9.23, p<.000). Captions and flowcharts had the least significant increase (T=-2.7, p=0.016 and T=-1.38, p=0.189 respectively); we believe students may have had some prior knowledge in these areas. Students' knowledge and understanding of surface diagrams increased the most, with the mean score increasing from 74.16 (range=56.25-87.50, SD=9.41) on the pre-test to a mean of 91.67 (range=75-100, SD=10.21) on the post-test (T=-5.6, p<0.000). Furthermore, students' abilities to explain the graphical devices and what they could learn from them increased. Please see Table 3 for example quotes from students' pre- and post-instruction.

Based on the pre- and post-assessment of their content knowledge, the students' scores increased from a mean of 50.93 (range=36.00-64.00, SD=9.13) to 83.47 (range=60.00-95.00, SD=9.19). This also shows a significant increase (T=-11.45, p<0.000).

Furthermore, most students were able to show their ability to generalize the information that was learned; for example, they drew surface diagrams of cupcakes and flowcharts showing the life cycle of a butterfly. As shown in Table 4, most students demonstrated *full mastery* of captions, surface diagrams, cross-sectional diagrams, and flowcharts. Of the four students who demonstrated *partial mastery* of captions, one student did not include an illustration to accompany the sentence, two students included one-word labels, and one student included a paragraph that told a story rather than providing information about the illustration. For surface diagrams, the students who demonstrated *partial mastery* did not use lines or arrows to connect labels to the parts, and the student who *did not demonstrate mastery* had an unscorable diagram that we could not read. When examining the flowcharts, one student who demonstrated *partial mastery* included a flowchart that read almost like a recipe while the other one lacked arrows, which led to ambiguity in the sequencing. The two students who *did not demonstrate mastery* included a surface diagram or a table in place of a flowchart. Although only seven students demonstrated *full mastery* of tables and eight demonstrated *partial mastery*, all students included rows and columns and all but two included numbers or short phrases. Eleven of the students included headings for the columns, but six of these students included redundant information with the headings. Therefore, most students understood the structure and purpose of the table but only had a partial understanding of how to create a complete one.

Limitations

Before explaining lessons that teachers could implement in their classrooms, we must acknowledge a few limitations of our study. This was an exploratory study performed in one classroom in one school with only 15 students participating in the pre- and post-assessment analysis. Furthermore, this was not designed as an experiment; there were no experimental and control groups. Therefore, we cannot generalize our findings to the greater population. We found, however, that the students' understanding of graphical devices and space improved, at least anecdotally, beyond what we had seen before.

Table 2

Descriptive Statistics and T-test Results of Pre- and Post- Graphical Device and Content Knowledge Assessments

Test Type	Number of students	Mean Pre	Standard Deviation Pre	Range Pre	Mean Post	Standard deviation Post	Range Post	T-test	P-Value
Caption	15	66.00	20.98	40-90	80.67	12.28	50-100	-2.75	.016
Surface Diagram	15	74.16	9.41	56.25-87.5	91.67	10.21	75-100	-5.61	.000*
Cross-sectional Diagram	15	62.91	8.98	43.75-81.25	75.67	11.38	56.25-87.50	-3.53	.003*
Table	15	62.78	7.63	43.75-93.75	80.00	11.38	41.66-100	-4.37	.001*
Flowcharts	15	68.75	15.04	25.00-93.75	79.17	19.76	43.75-100	-1.38	.189
Overall Graphical devices	15	66.99	5.88	13.75-75.92	82.63	8.24	68.33-96.25	-9.23	.000*
Content Assessment	15	50.93	9.13	36-64	83.47	9.19	60-95	-11.45	.000*

*Significant at $p<.01$

Table 3

Examples Student Explanations of Graphical Devices Pre- and Post-Instruction

Student	Comment Pre	Comments Post/during
Hector	When shown a diagram and asked what it was called: "I don't know, it explains what the picture is about."	"A diagram shows a picture with labels"
Brandon	"For telling what the picture is about (diagram)"	"A Diagram…Showing a picture and labeling the parts of that picture."
Melanie	"They help things" (Cross sectional Diagram)	"Cross sectional diagram…They show the parts and label them"
Frankie	"To show up close of pictures and extra information."	"Caption…Describe what the picture is about."

Table 4

Number of Students Who Demonstrated Full Mastery, Partial Mastery, or Did Not Demonstrate Mastery When Creating Each Type of Graphical Device.

	Demonstrates Full Mastery	Demonstrates Partial Mastery	Does Not Demonstrate Mastery
Caption	11	4	0
Surface Diagram	13	1	1
Cross-sectional Diagram	15	0	0
Table	7	8	0
Flowcharts	11	2	2

Bringing the Graphics into the Limelight

Throughout the program we used a variety of lessons that incorporated the graphical devices. The goals were to teach the students what the devices were, how to interpret them, and how to create their own. As explained above, we designed lessons to teach science standards that incorporated the graphical devices. Five of these lessons that we found most beneficial included Drag and Drop, Graphical Device Hunt, Question the Graphic, Compare and Contrast, and Creating Graphical Devices, which are described below. One important idea to remember is that, although we used these lessons to teach about outer space, they can be altered to fit any content or subject area.

Drag and Drop

Using the interactive whiteboard and software, we created games in which the objective was for the students to drag the information to the correct spot on the graphical device. For example, for the flowchart, we presented the students with a flowchart of the phases of the moon with the moon images missing but the arrows in place. We discussed why the arrows were present and then had the students drag and drop the moons into their respective places (please see Figure 4). For other games, you may have students drag and drop labels to indicate parts of a diagram, arrows to indicate movement in a flowchart, or phrases to caption a photograph. These activities could be altered for those who do not have an interactive whiteboard by using paper and tape or glue. Furthermore, in order to scaffold the students' understanding of the graphical devices, the amount of information students need to place can range from only a few words to putting the whole graphical device together.

Figure 4. Drag and drop of the phases of the moon.

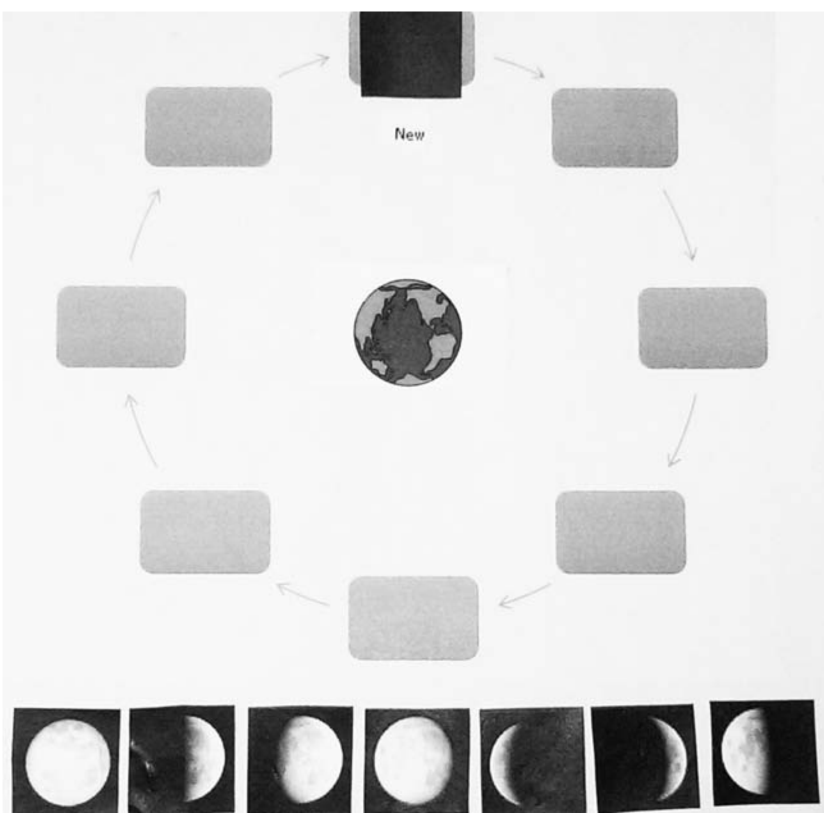


Figure 5. Example books to teach different graphical devices.

Surface Diagrams / Cross-sectional Diagrams

Marchesi, S.(2008). *Who is Neil Armstrong?* New York, N.Y.: Grosset & Dunlap.

Captions

Steele, P. (2005). *Galileo: The genius who charted the universe* (A Marshall ed.).

Washington, D.C.: National Geographic.

Captions / Cross-sectional Diagrams

Floca, B. (2009). *Moonshot: The flight of Apollo 11*. New York: Atheneum Books for

Young Readers.

Flowcharts / Surfaces Diagrams / Captions / Cross-sectional Diagrams

Mist, R. (2008). *The great big book of the solar system* (Scholastic ed.). Irvine, Calif.:

QEB Pub.

Tables / Surface Diagrams / Cross-sectional Diagrams

Berger, M., & Berger, G. (2005). *Think factory: Solar system*. New York: Scholastic.

Surface Diagrams / Captions / Flowcharts

Gibbons, G. (1997). *The moon book*. New York: Holiday House.

Surface Diagrams / Captions

Goodman, S., & Slack, M. (2013). *How do you burp in space?: And other tips every*

space tourist needs to know. New York: Scholastic.

Tables / Diagrams/ Cross-Sectional Diagrams / Flowcharts

Mitton, J., & Mitton, S. (1998). *Scholastic encyclopedia of space*. New York: Scholastic.

Tables / Flowcharts / Cross-sectional Diagrams /Surface Diagrams / Captions

DK publishing (2010). *Space: A visual encyclopedia.* London: Dorling Kindersley

Graphical Device Hunts

After teaching the students about the different graphical devices, students looked through books, "hunting" for the graphical devices we had discussed. We circulated the room to confirm that they had correctly identified the feature being learned. As a group we also discussed if the devices found fit all the criteria that we had determined important in our lesson – after all, not all graphical devices are made the same. Students continued hunting for and sharing graphical devices throughout the day. Please see Figure 5 for books about space that contain model graphical devices.

Question the Graphic

Once students have found specific devices, it is important for them to understand whether or not the graphic will assist them in learning relevant information. During this lesson, we taught students to ask themselves questions about the graphic:

1. Is the graphic relevant to the written text or just a decoration on the page? (If the answer is decoration, you can skip this graphic.)

Some books include graphics that brighten up the page, but have little to no relation to the topic. These graphics are primarily decorative in nature. For example, when reading *Astronomy: Out of This World* (Green, 2009), students noted that the written text provided information about the different planets, but the graphics, though labeled as a planet, are cartoons of what a planet might look like as a person. Studying these graphics would not provide information about the planets.

2. Is this graphic related to what I want to learn? (If the answer is no, you can skip this graphic.)

Just as readers do not need to read all sections of an informational text, they do not need to read all graphics. For instance, if a reader is researching Mars, a table that includes information about Jupiter does not need to be studied.

3. If yes, what can I learn from the graphic?

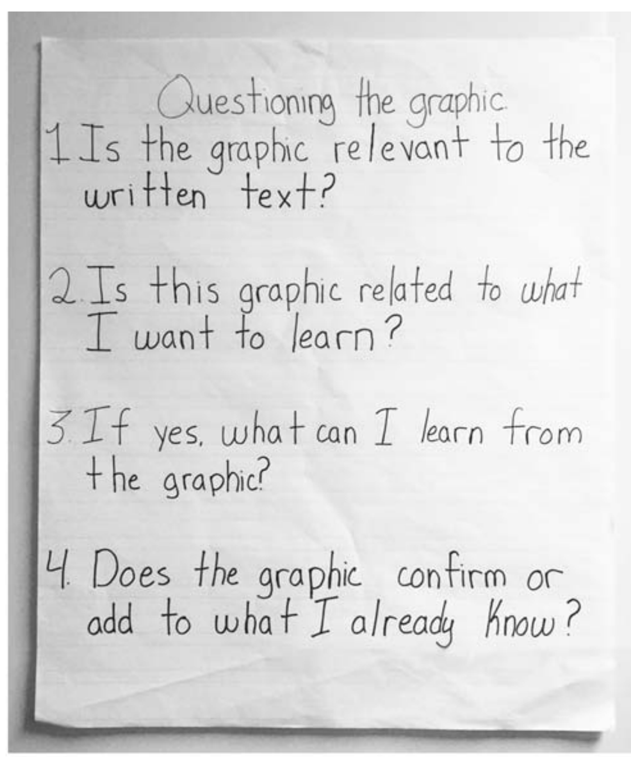
Once the reader has determined whether she should study the graphic, she can then think about what information she can gain from it. Just as we learn from written text, we need to take the time to learn from the graphic.

4. Does the graphic confirm or add to what I already know?

The information contained in the graphic might confirm or add to what the students have read about in the written text associated with it or other books. Just as with information gained from written text, readers need to think about how information gained from graphics fits into their schema.

To help students internalize these questions, we modeled responding to these questions and created an anchor chart (see Figure 6) which we reviewed with students as we read and discussed different graphics.

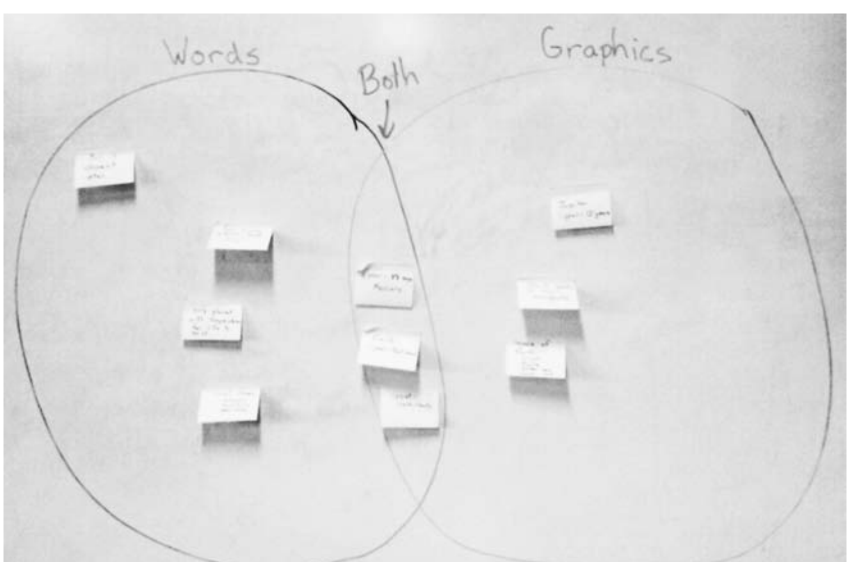
Figure 6. Anchor chart for Questioning the Graphic.



Compare and Contrast

To further develop the idea that readers can learn from both the written text and graphical devices, we employed a variation of the Venn diagram (Norman & Roberts, 2013), labeling the left circle "Words" and the right "Graphics." We read a book, such as *Think Factory: Solar System* (Berger & Berger, 2005), two times: first without showing the graphics, and then while studying them. During the first read, the students' job was to listen very carefully and be ready to share what they have learned from the words. After reading a portion of the text, we stopped and asked the children to share these ideas. We wrote their responses on sticky notes, and placed them in the "Words" section of the Venn diagram. We repeated this process until we had read the entire text. Next, we reread, paying particular attention to what we could learn by studying the graphical devices. Again, we stopped and wrote down what students learned, this time from the graphics. These sticky notes we placed in the "Graphics" circle. When the text provided the information in both the words and the graphics, we moved that sticky note to the center of the Venn diagram (See Figure 7 for an example).

Figure 7. Compare and contrast activity Venn diagram.



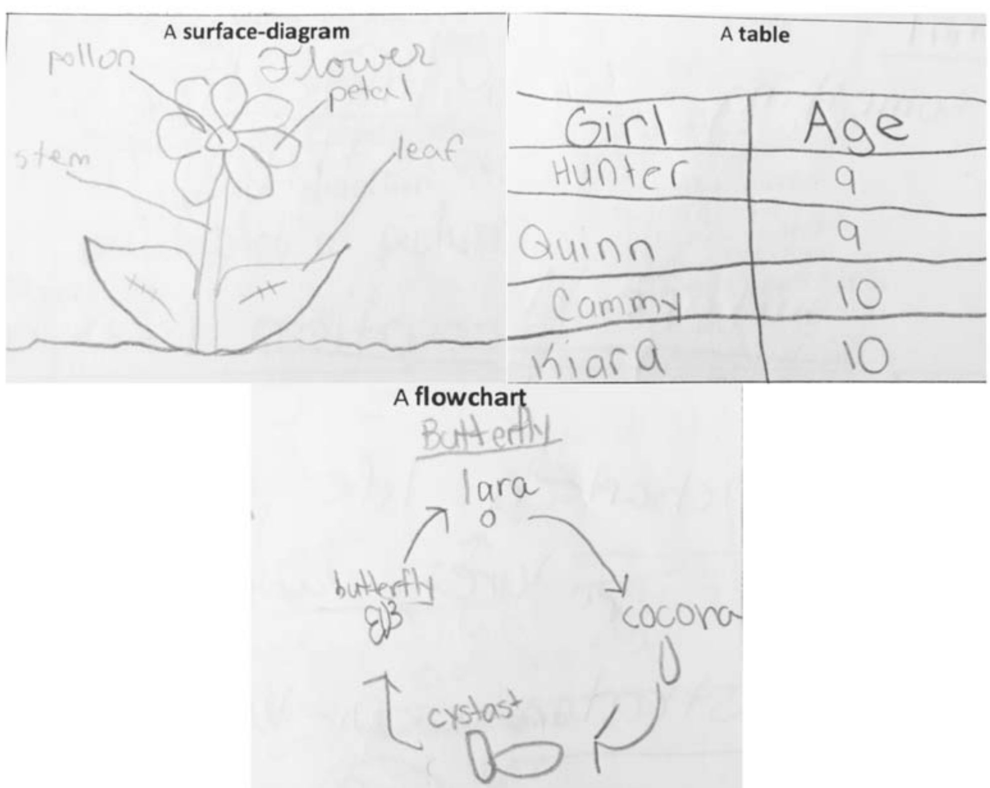
Creating Graphical Devices

After completing the lessons about each of the graphical devices, we gave students an assignment to create the graphical device. The objective was to see if the students could create space-specific graphics as well as generalize this skill to other topics. For one space activity, we gave the students a reading with different data on planets and had them create their own table that fit the reading. We scaffolded this by first setting up the table with the heading and having the students fill in the information (see Figure 8 for a student example), next having the student come up with the heading as a class, and finally having the student create the entire table on their own. Later they were asked to create a device on a topic of their choosing. For these, students drew diagrams of cupcakes or cars, flowcharts on how to bake cupcakes or put a toy together, and much more. Please see Figure 9 for an example of student work from this activity. This activity gave students the opportunity to apply what they had learned about each of the graphical devices. As a teacher, these activities will allow you to know if the students are able to use what they have learned about graphical devices across topics and content areas. The students enjoyed this activity because they were able to be creative with the different graphical devices.

Figure 8. Student created table using a text.

Name of Planet	Distance from the sun	Gases that make up Atmosphere	Layers that make up the planet	Number of moons	Time it takes to revolve around the sun as compared to earth	Diameter of the planet
Jupiter	484,000,000 mi	hydrogen helium	Liquid hydrogen Metalic hydrogen Core	63	12 years	88,846 mi
Saturn	885,900,000 mi	hydrogen helium	Atmosphere Ice Water High pressure Ice Core	36	28.4 years	74,897 mi
Uranus	1784,000,000 mi	hydrogen helium methane	Outer Atmosphere Atmosphere Mantle Core	27	84 years	31,763 mi
Neptune	2,795,000,000 mi	methane and..	Atmosphere Mantle Core	13	165 years	30,775 mi

Figure 9. Sample student work from Create Your Own Graphical Device lesson.



What Can Researchers and Teachers Do with This Information?

As stated earlier, this study was an exploratory study performed with one class in one school around one subject. Although the results are promising, further study is needed to truly understand how best to teach readers to decode and comprehend graphics. For now, to bring students to a higher level of reading comprehension, teachers must remember to never skip the graphical devices. We must model for our students how to read and create each of these. Combining graphical devices with content area material should not be seen as extra; it should be integrated into instruction to enhance understanding of both the devices and the content.

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