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The Usefulness of Graphic Organizers in Enhancing Science Learning

Abstract

The purpose of this study was to investigate how graphic organizers can be used to further learning in science class. Graphic organizers facilitate learning in content areas by providing clear visualizations of ideas and facilitating student reflection. Research was conducted in a sixth grade science class with 25 students during a weather unit, and it was found that in using graphic organizers in science class, students were successful in using the open-endedness of graphic organizers to gain a more thorough understanding of concepts. In utilizing literacy strategies like graphic organizers in the content areas, student learning and independence is increased and they are more prepared to practice these skills independently throughout life.

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The Usefulness of Graphic Organizers in Enhancing Science Learning

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The purpose of this study was to investigate how graphic organizers can be used to further learning in science class. Graphic organizers facilitate learning in content areas by providing clear visualizations of ideas and facilitating student reflection. Research was conducted in a sixth grade science class with 25 students during a weather unit, and it was found that in using graphic organizers in science class, students were successful in using the open-endedness of graphic organizers to gain a more thorough understanding of concepts. In utilizing literacy strategies like graphic organizers in the content areas, student learning and independence is increased and they are more prepared to practice these skills independently throughout life.

The Usefulness of Graphic Organizers in Improving Science Learning

A successful language user utilizes language for a variety of purposes—knowledge acquisition and communication among others. One indication of a successful language user is the ability to utilize literacy skills across content areas. Likewise, an unsuccessful language user struggles to understand information in content areas. Often teachers see students who are not practicing literacy strategies that could assist the student in approaching new and foreign topics such as those found in a science class. While teaching students about heat energy in the atmosphere, students explored the ways that energy reaches Earth from the sun as well as ways that heat energy can be transferred between objects. As they were learning these concepts, students were referring to these topics interchangeably when, in actuality, they are two separate ideas. By organizing the information visually, students have a more concrete description of the concepts.

Science content can seem difficult, and even intimidating, to many students. If teachers, however, encourage students to access those valuable reading and writing strategies in other content areas, students will find new ways to think about the given content and therefore internalize a more thorough understanding.

By specifically examining how students use graphic organizers in science, we see the level at which these students are able to organize thoughts and information. Additionally, when students effectively utilize graphic organizers to manage science knowledge, they are able to organize and reflect upon information gathered. This process ultimately leads to a more thorough understanding of the content.

Theoretical Framework

Literacy processes are complex entities that are constantly being influenced by changes among society. As described by Freebody and Luke, "...literacy is a multifaceted set of social practices with a material technology, entailing code breaking, participation with the knowledge of the text, social uses of text, and analyses/critique of the text" (1990, p. 15). These oral and written interactions with other members of society are "multifaceted" in the sense that every literacy event is comprehensive, complex, and unique with many factors influencing its effectiveness (Kucer, 2005). Because of the complexity of each literacy event, it is imperative for students to understand how to best make use of literacy practices.

In order for students to successfully use language as they navigate various areas of their lives, they must explore various strategies to do so. Additionally, students need to be reflective in analyzing and choosing those strategies that work for them. The totality of literacy acquisition evolves as a child constantly observes communication among others (Goodman, 2001; Kucer, 2005). With this, the child tries out language for him or herself, making necessary adjustments throughout the process (Kucer, 2005). Still, the individual is always supported by those close to him or her in generating meanings through literacy events (Goodman, 2001; Kucer, 2005). Specifically, as a child begins to use language as he or she has observed, the child is compared to a scientist in that he or she gathers information about oral and written language, generates language rules and practices (or hypotheses) for each language form, tests those rules, and alters the language practices accordingly (Kucer, 2005). Gee (2001) describes this process to be acquisition (taking in something new subconsciously without formal teaching), as opposed to learning (taking in something new consciously with teaching). So much is acquired during these experiences that it is important for teachers to provide opportunities for this exploration and

construction (for example, workshop settings), and also to not be so quick to correct children the first time around—guide them through figuring out language strategies in order to foster meaningful experiences (Gee, 2001; Goodman, 2001; Kucer, 2005).

While a learner's efforts are significant, Kucer (2005) states that often, while children are acquiring the skills associated with literacy use, the process may seem like it is progressing in an unnatural fashion full of advances and regressions. In examining the child as a scientist, however, it is simply that the child is constantly making adjustments to his or her language practices. In acquiring language behaviors in this organic fashion, children are truly learning and internalizing language practices. To hone these independent learning skills across the content areas, we need to provide opportunities for students to practice literacy skills. In using graphic organizers in the content areas, students are given a balance of structure and independence that is supportive of their learning.

Research Question

If literacy is understood to be a social practice through which children acquire knowledge and graphic organizers are seen to support literacy learning by scaffolding learning experiences, then it is important to ask the question *In what ways do graphic organizers support student learning of science concepts?* In order to better understand how students use literacy strategies in content areas, students' uses of various graphic organizers in science class will be evaluated. Through this process, it will be determined how students are using graphic organizers to increase comprehension and what factors contribute to a higher level of comprehension.

Synthesis of Literature

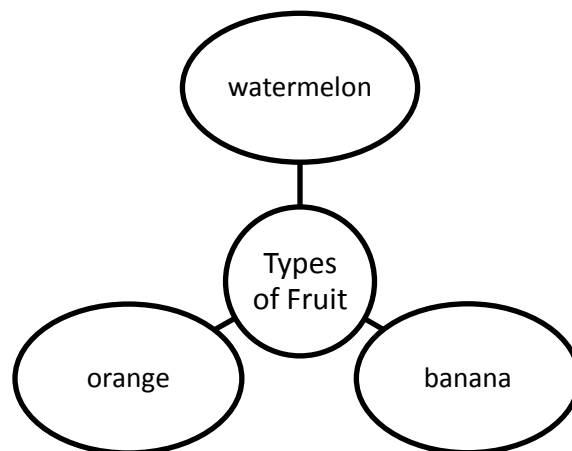
What is a Graphic Organizer?

Simply stated, a graphic organizer is a “visual representation of knowledge” regarding a certain concept (Bromley, Irwin-DeVitis, & Modlo, 1999). More specifically, graphic organizers are arranged in a way that best shows the interrelatedness of pieces of information presented (Horton, Lovitt, & Bergerud, 1990). When choosing a graphic organizer, it is essential to consider the learning outcome for the concepts being taught; in doing so, the graphic organizer will help the learner understand the material. Graphic organizers have been sorted into four categories according to the interrelatedness of information to be presented in a particular graphic organizer (Ermis, 2008; Struble, 2007). These categories include conceptual, hierarchical, cyclical, and sequential.

Conceptual Graphic Organizers

A conceptual graphic organizer is suitable for presenting a central idea with supporting information. Conceptual graphic organizers include concept maps, Venn diagrams, and KWL, to name a few (Struble, 2007).

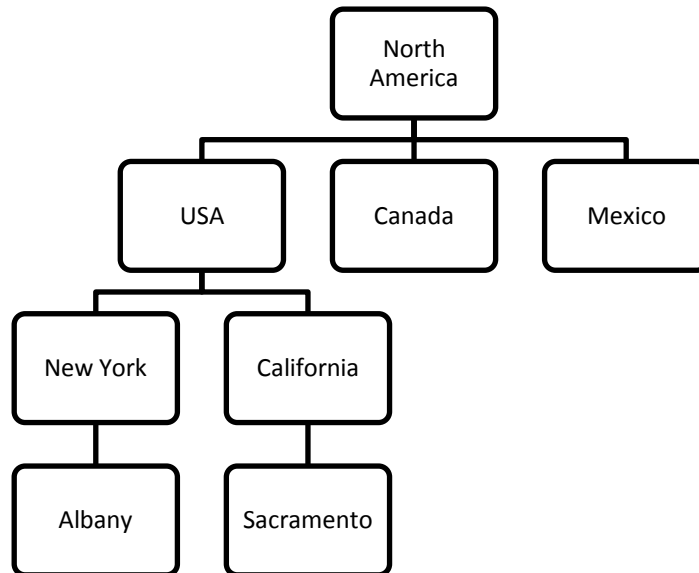
Example:



Hierarchical Graphic Organizers

Hierarchical graphic organizers rank information according to such qualities as importance and have sublevels to show such. Examples of these include classifying charts, branching diagrams, and topic/subtopic webs (Struble, 2007).

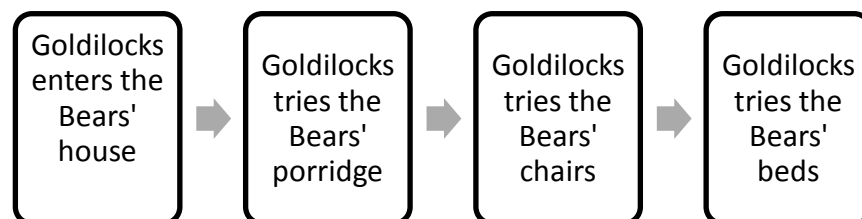
Example:



Sequential Graphic Organizers

In order to show events that happen in sequence, one uses a sequential graphic organizer. Examples of sequential graphic organizers include cause/effect, problem/solution, and story boards (Struble, 2007).

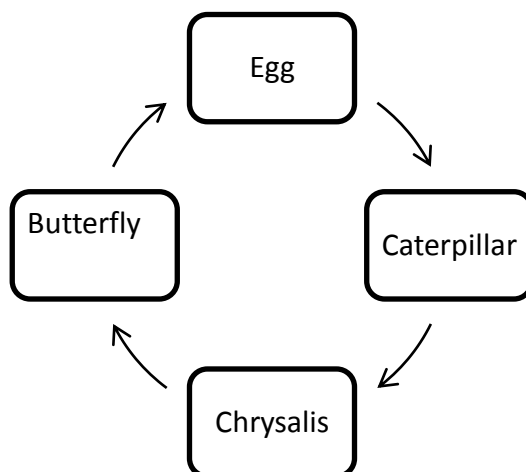
Example:



Cyclical Graphic Organizers

These graphic organizers are designed to show the natural cycle of various concepts (Struble, 2007). A commonly used cyclical graphic organizer is an organism life cycle chart.

Example:

*Benefits of Using Graphic Organizers in the Content Areas*

Based on the research presented, utilizing graphic organizers in the content areas furthers student understanding of material that can otherwise be difficult; there are a variety of factors that influence this. Darch and Carnine (1986) state that while students need to acquire higher order comprehension skills, such as evaluative and creative, graphic organizers provide a solid foundation for understanding literal information; armed with the more literal concepts, students (particularly struggling learners) are more able to develop a deeper understanding of content. Additionally, the structure of graphic organizers is more suited for comprehension as compared with traditional linear note-taking of information; graphic organizers are able to show the relationship among concepts (Ermis, 2008; Fisher, 2001; Robinson, Beth, Odom, Hsieh, Vanderveen, & Katayama, 2006). Ermis (2008) points out that when students are reading nonfiction texts, they need to develop specific strategies to approach such specific challenges as

varying organizational patterns, new vocabulary, and the assumption of prior knowledge.

Graphic organizers assist readers in approaching texts that include such challenges by arranging information systematically. With this logical organization, readers have minimized some of the challenges and can advance deeper into the text.

Research on Graphic Organizers

Research on graphic organizers and their effects on the learning process has increased over the past twenty-five years. Graphic organizers are spatial displays that use lines, arrows, and various designs to describe information and the relationships among concepts (Darch & Carnine, 1986). Through these research projects, individuals have compared the use of graphic organizers to traditional linear note-taking strategies and explored their usefulness in acquiring content area knowledge (cite). Additionally, the extent of student participation has been investigated evaluating the various implementations of graphic organizers (cite). Other research has been performed to examine the effects of graphic organizer use on students with learning difficulties (cite). In investigating the use of graphic organizers to encourage comprehension, researchers have seen benefits in student learning.

In a study performed by Ermis (2008), second-, fourth-, and fifth-grade students were examined using nonfiction texts. A pretest was given to assess current knowledge about the given information from the selected texts. Groups then read informational texts at the appropriate level. While reading, the traditional instruction group held a class discussion about the information presented in the text, while the graphic organizer group utilized graphic organizers to guide discussions. Results from the posttest favored the use of graphic organizers to manage information when reading informational texts. Specifically, the traditional instruction groups gained an average of 35% from pretest to posttest, while the graphic organizer groups

gained an average of 45% from pretest to posttest. These results greatly favor the use of graphic organizers to monitor comprehension while reading informational texts.

Similarly, Darch and Carnine (1986) focused their research on fourth-, fifth-, and sixth-grade students with learning disabilities to examine how the use of graphic organizers impacted their learning in social studies and science classes. In this case, graphic organizers were used to present information to students as opposed to review information with students as similar studies have (cite). The individuals selected for research were twenty-four students who had been classified as learning disabled by their school districts and were assigned to resource classrooms. The two groups were taught the same content, but in two different ways—one group was taught the information using graphic organizers while the second group used a method that involved reading about the content and answering questions about the information. In analyzing pretests and posttests, students taught using graphic organizers outperformed others by scoring an average of 86% on the posttest compared to 56% for the text study group. An additional consideration that was measured regards the students' attitudes toward the learning process; students in the graphic organizer group expressed more significantly that they felt as though they learned a lot (Darch & Carnine, 1986).

In a similar study performed by Horton, Lovitt, and Bergerud (1990), the use of graphic organizers was investigated using secondary students in social studies and science. In this case, the researchers examined not only students with learning disabilities, but also students in general education. Specifically, this study compared the use of teacher-directed graphic organizers and self-study using graphic organizers. With the teacher-directed graphic organizers, the teacher instructed students to read a text selection then led the class as they filled in the graphic organizer, explaining how the pieces of information corresponded to one another. The self-

study, on the other hand, involved reading a selection, studying, and filling in the graphic organizer independently. It was clear in this study that teacher-directed implementation of graphic organizers was more effective in facilitating understanding; for example, students with learning disabilities scored an average of 70% on the given assessment when taught with a teacher-directed graphic organizer compared to 20% with self-study. The students in general education scored an average of 86% with teacher direction and 56% with self-study (Horton, Lovitt, & Bergerud, 1990). This study reinforces the results from the previous study in proving that the use of graphic organizers in acquiring information is beneficial, but also furthers the research in finding that graphic organizers are more effective when taught and explained by a teacher.

As shown in Horton, Lovitt, and Bergerud's study, certain implementations of graphic organizers are more effective than others. Robinson et al. (2006) explored the use of partially-complete graphic organizers in order to promote student independence. With partial graphic organizers, students are provided with a graphic organizer that has portions already complete in order to guide comprehension while students fill in the remainder of the graphic organizer independently. Because this study was performed at the undergraduate level, researchers compared partial graphic organizer use with completed graphic organizers; students who used partial graphic organizers performed higher on the test than those students who received a completed graphic organizer. What is more influential are the findings that students who were given the partial graphic organizer were more likely to independently utilize graphic organizers by the end of the course as compared to their independent note-taking style at the beginning of the course (Robinson et al., 2006).

While completing graphic organizers, teachers have observed a higher level of engagement, accountability, and creativity among the students (Fisher, 2001, Gieselmann, 2008, and Robinson et al., 2006).

A long term, and highly valuable, outcome of utilizing graphic organizers to acquire content is that it teaches students to evaluate and classify information according to a variety of features. With this, students are involved in a multi-step process. This involves reading and processing content, then organizing the information by judging aspects of the information. This skill is one that is carried over to new situations and facilitates the learning process across various concepts (Gieselmann, 2008).

Methods

In exploring the use of graphic organizers to further comprehension of science content, a sixth grade class was examined. This 25-student class is part of Veteran Intermediate School, which houses 1,000 fourth, fifth, and sixth grade students. Veteran is a large suburb of Rochester, New York. Veteran Central School District has been designated a “high performing school district” by New York State.

The class targeted in this study includes 25 students who are 11 and 12 years old. In the class, there are thirteen boys and twelve girls. Twenty-four students are Caucasian and one student is African American. Two of the students have 504 plans (hearing impairment and attention deficit hyperactivity disorder), and one student is currently be classified with an Individualized Education Plan for a learning disability. The researcher is also the classroom teacher, who is a long-term substitute for the classroom. The teacher is in the classroom from late January to mid-March; data collection occurred throughout the month of February. She is in her second year of teaching and is new to Veteran Schools this year. Additionally, the teacher is

completing her Masters degree in literacy at Saint John Fisher College. Her certification areas are in childhood education (grades one through six), special education (grades one through six), early childhood education (birth through grade two), and dance education (kindergarten through grade 12).

In order to examine the use of graphic organizers in science, graphic organizers were integrated to science instruction during a weather and climate unit. Students were taught using graphic organizers to show the interrelation of science concepts. Graphic organizers that were used include a concept map for solar energy travel (Appendix A), a compare and contrast matrix for heat transfer (Appendix B), a water cycle diagram (Appendix C), and a concept map for wind types. These graphic organizers were used as teaching tools, as well as assessment tools. To evaluate the impact that these graphic organizers had on student comprehension, the teacher used observations and interviews. These observations were conducted each time that graphic organizers were taught, which were four times over the course of three weeks. Observations were made while teaching whole group science lessons by paying specific attention to student engagement and participation with consideration to previous science lessons. With the solar energy travel concept map and the heat transfer matrix, assessments were given to examine student learning based on the content taught with those graphic organizers. For these assessments, students were asked to organize content into graphic organizers, as well as use graphic organizers to recall information learned. Finally, interviews were conducted with students to understand their reflections on using graphic organizers (Appendix D). The interviews were conducted in a conversation format with students presenting their reflections and commenting on one another's ideas.

Ensuring Trustworthiness

According to Mills (2007), researchers need to be aware of the credibility, transferability, dependability, and confirmability of their studies. Credibility is the ability to be open-minded about the variables that may arise during research. In order to ensure credibility in this study, I have evaluated the use of graphic organizers from multiple perspectives including those of both the teacher and the students. Additionally, data was collected through observation, interviews, and student work to take into account various perspectives on graphic organizers. Transferability is the understanding that data is specific to the situation in which it is occurring and being able to appropriately evaluate the effects of the context of the research (Mills, 2007). The researcher considered the data and its context specifically so that transferability was present. Mills (2007) also describes the importance of dependability in action research. Dependability refers to the strength of research in that the methods reinforce one another. My research was dependable in that multiple sources of data were considered and each supported one another. Finally, the confirmability of research is lack of bias in a study (Mills, 2007). This was achieved by comparing and contrasting sources of data. It also was accomplished by examining the research for subjectivity throughout the process.

Data Collection

Data collection for this study included teacher reflection, student interviews, and gathering student work samples. Teacher reflections were recorded after teaching lessons that involved the use of graphic organizers. Reflections alluded to the teaching process, student receptivity, and student participation. Student interviews were also conducted; these involved discussions with students concerning their perspectives on using graphic organizers and the impact they had on their learning. Finally, student work was gathered and analyzed according to

the students' abilities to use the information learned through the graphic organizers and transfer it to other contexts.

Findings

In implementing graphic organizers in a sixth grade science class and gathering reflections from the students who used them, four themes emerged. For each of those themes, the greatest amount of information was gathered in my teaching observations and discussions with students. Various observations were made regarding student participation and ownership, idea accessibility, visual representation, and idea substitution.

Student Participation and Ownership

As with any class activity, participation levels among students varied greatly. Darch and Carnine (1986) describe a benefit of graphic organizers to be the ability to address various depths of comprehension; my research had similar findings. As evidenced by students' graphic organizers, particularly the heat transfer chart, the degree of student ownership varied (in this case, "student ownership" refers to the degree to which students independently utilized the graphic organizer to extend comprehension). For example, when students utilized a chart to describe the three types of heat transfer and provide examples, some students restated heat transfer examples as discussed during the whole group conversation, which demonstrates a lesser level of ownership. Others, however, demonstrated the ability to extend and transfer knowledge about each type of heat transfer to everyday scenarios.

This is indication as to how graphic organizers were used to address students' varying levels of comprehension and readiness for extension. Graphic organizers provided differentiated material in that students were free to customize ideas to their own thought processes and establish a solid foundation for extending knowledge. Again, for those students who were not

prepared to broaden the main ideas, they were able to provide basic information to establish a solid foundation for further learning. Likewise, students who were ready for a deeper examination provided a more insightful analysis. In the examples below, one student applied her knowledge about convection heat transfer to independently realize that a hair dryer utilizes convection to transfer heat by heating air, while others restated examples discussed in class such as a furnace warming a house.

	1. Convection	2. Conduction	3. Radiation
How it works	The heat source heats the air, which brings the heat to another object	Moving heat directly from one thing to another.	The sun's rays making a certain thing warm.
An example of how heat is transferred in this process	a furnace warming a house	Hot sand makes your feet hot	The way that the sun's rays make you feel warm

	1. Convection	2. Conduction	3. Radiation
How it works	The heat source heats the air, which brings the heat to another object	direct transfer of heat from one object to another	electromagnetic rays warm the earth from the sun
An example of how heat is transferred in this process	hair dryer	Hot sand makes your feet hot	The way that the sun's rays make you feel warm

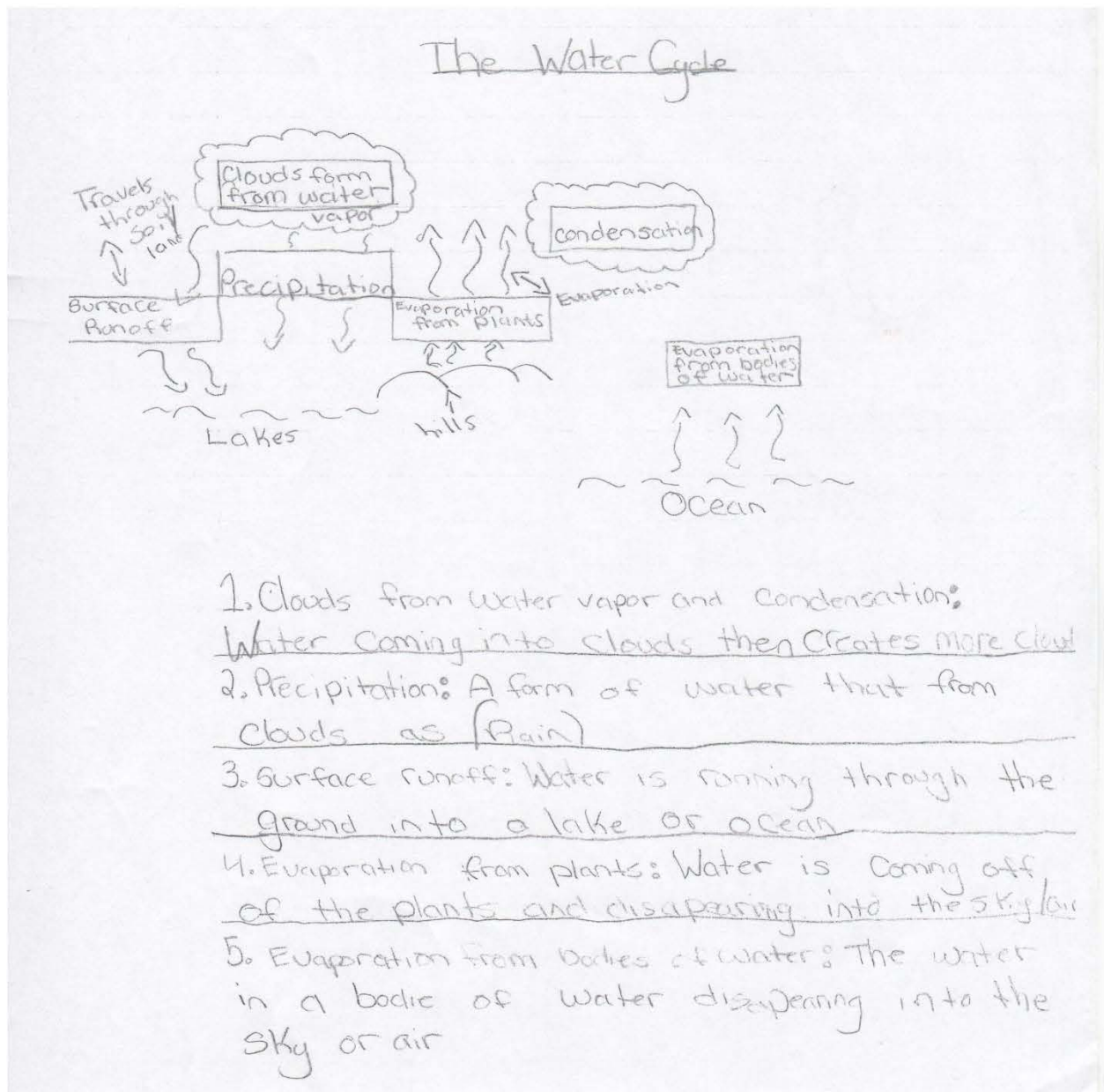
Idea Accessibility

According to student interviews (Appendix D), most students found that ideas arranged in a graphic organizer were more easily processed when compared with “note-taking.” This group of students refers to note-taking as using fill-in-the-blank statements and lists (not including hierarchical outlines). Multiple students alluded to the fact that graphic organizers allow them to neatly and clearly organize information. With this, they found that it helped them process and retain the information more efficiently. Additionally, students pointed out that the use of graphic organizers was effective in recalling information on tests. Specifically, some students utilized the graphic organizers as a study tool while others referenced them to make flashcards of the content. One student shared that “graphic organizers have a focus and helped me study.” While I do not believe that students should see a test as a goal compared to the ultimate learning that can occur, knowledge on tests represents a longer retention of information. By using graphic organizers to process information, students felt as though they could retain the information for a longer period of time when compared with note-taking.

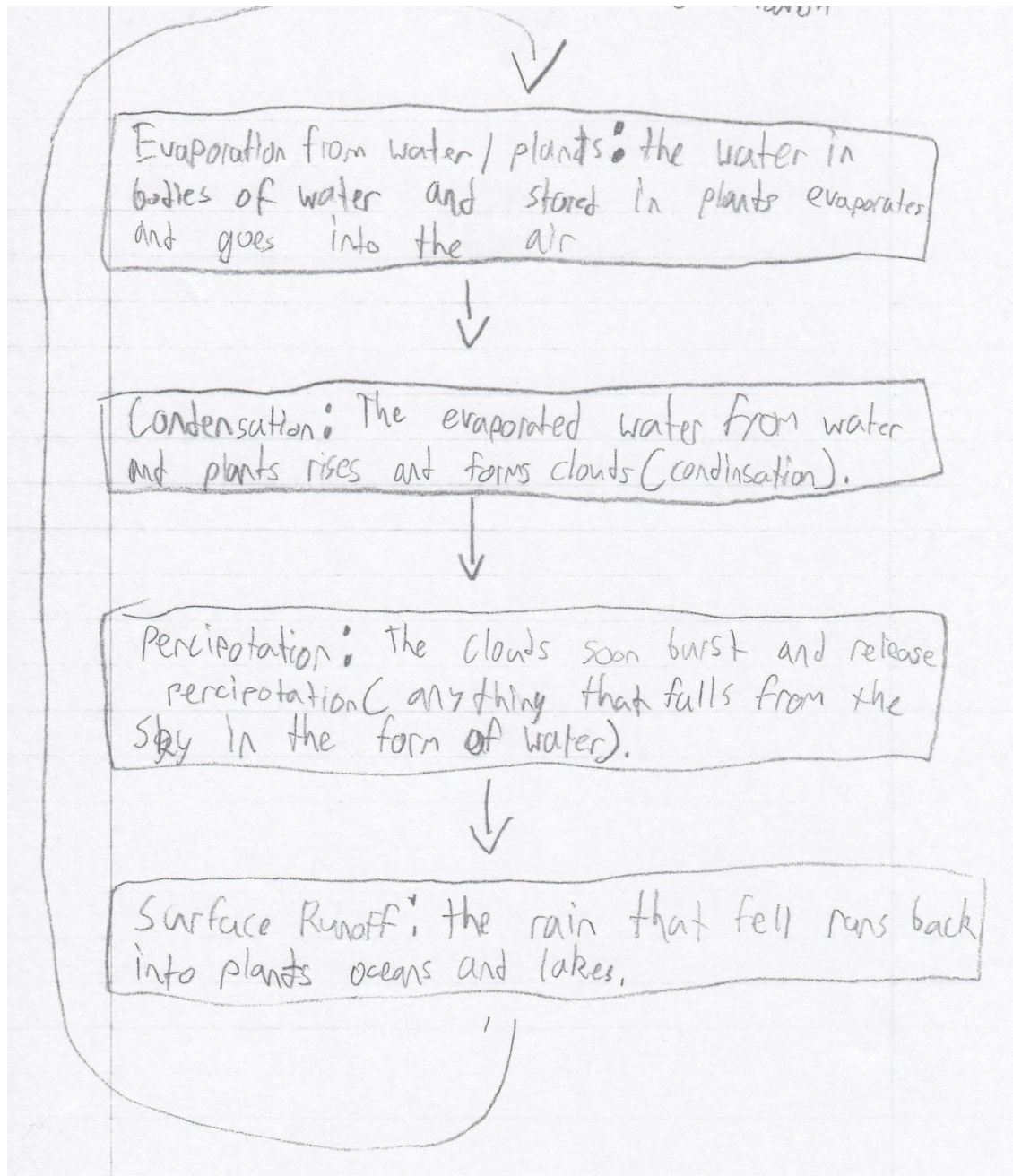
Visual Representation

A key realization demonstrated by the students’ reflections on the use of graphic organizers in learning science content was the visual representation of information and its interconnectivity. Students shared that by organizing information in such a way that shows relationships among ideas, they were able to understand the content more readily. A student explained that “graphic organizers are neater and they actually answer questions; it’s easier because notes are just memorizing and the graphic organizers showed what things meant compared to each other.” This student is expressing that graphic organizers help him relate ideas to one another because of their visual qualities.

Certain features in visual representations provide a quick response to aid in processing information relationships. For example, by using arrows to show the direction of water flow in the water cycle, students immediately process the sequential order of stages (shown below).



An additional example involves using simple shapes to demonstrate the boundaries between objects. When examining the means by which water travels through the atmosphere in the water cycle, some students outlined the separate ideas in shapes that showed the distinction between different methods (shown below).



A final example involves demonstrating the hierarchy and categorization of ideas. In using organizers that show the “umbrella” idea and exhibit the specificity of information, learners can store that information more efficiently. While the effects of specific features of graphic organizers such as outlines and arrows cannot be measured accurately by my data, my observations suggest that they are helpful in facilitating comprehension as shared by students when discussing the usefulness of graphic organizers. In listening to students reflect on graphic organizer use, their statements exemplified independence in learning the ideas by saying things like “graphic organizers helped me on the test because they showed me what things meant” and “they made me remember.”

Idea Substitution

In using graphic organizers to facilitate student comprehension of science content, there was one hindrance observed. During one lesson, the class examined two closely related topics—solar energy travel and heat transfer. Solar energy travel refers to the three ways that energy reaches Earth from the sun and heat transfer refers to how heat energy can be moved from one substance to another. A graphic organizer was used for each—a conceptual map for solar energy travel and a chart for heat transfer. When discussing the two areas, some students substituted the term that refer to types of heat transfer for solar energy travel and vice versa. My reflections accredit this to two issues. The first is that there are three types for each (heat transfer and solar energy travel) and the second is that the topics were taught on the same day. Even though students demonstrated difficulty deciphering these two topics in this case, I do not believe that it can be accredited to the use of graphic organizers. However, in the future, I would teach these topics separately to avoid confusion or even utilize a hierarchical graphic organizer to show that heat transfer between substances occurs once energy has reached Earth.

Implications and Conclusion

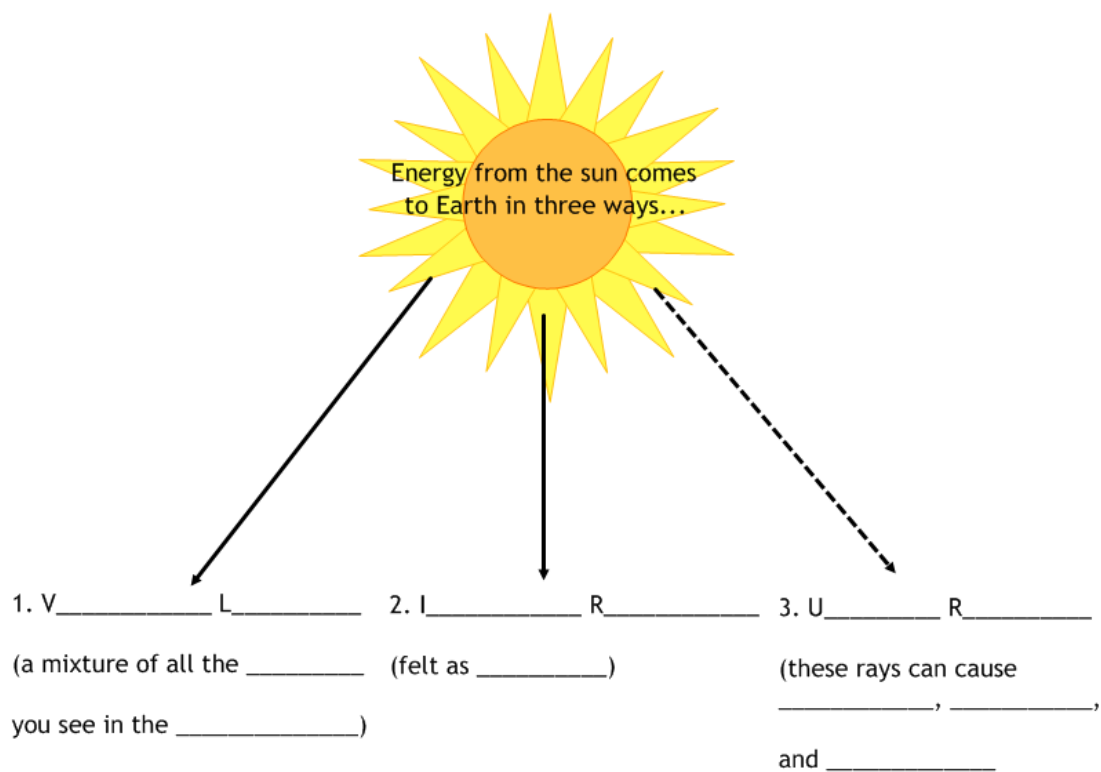
Based on the information gathered through studying literature and classroom research, graphic organizers facilitate student comprehension of science content by showing the interrelatedness of ideas, providing visual cues to help students process the information, and allowing students to direct their own learning by keeping graphic organizers open to interpretation and independent thinking. In using graphic organizers as a teaching tool, teachers can provide differentiated instruction suited for all learners' needs as well as a format that is easily accessible for students. While science topics may seem abstract, graphic organizers are a tool to facilitate understanding. More than facilitating understanding, however, I found that in using graphic organizers to learn science concepts, students took on a more reflective and accountable role in learning the information.

In this research, I found certain choices to be significant in utilizing graphic organizers in my sixth grade science class. First, graphic organizers are most effective when chosen carefully. It is important to examine the various types of graphic organizers and select the one that best matches targeted learning outcome of the specific content and your students' learning styles. Second, as with any lesson, provide appropriate scaffolding to support the varying needs of all students; students need instruction and practice in using graphic organizers but also can thrive on the open-endedness of graphic organizers. Finally, once students are ready, broaden the use of graphic organizers; students can use them independently and teachers can use them as assessment tools.

Students can constantly use literacy skills to further their learning. In encouraging independence in student understanding, we can teach students to be literacy practitioners by using literacy strategies across all content areas. Graphic organizers can be used as tools to

facilitate student understanding. In using them, teachers can help students develop effective strategies in approaching difficult material to further lifelong learning.

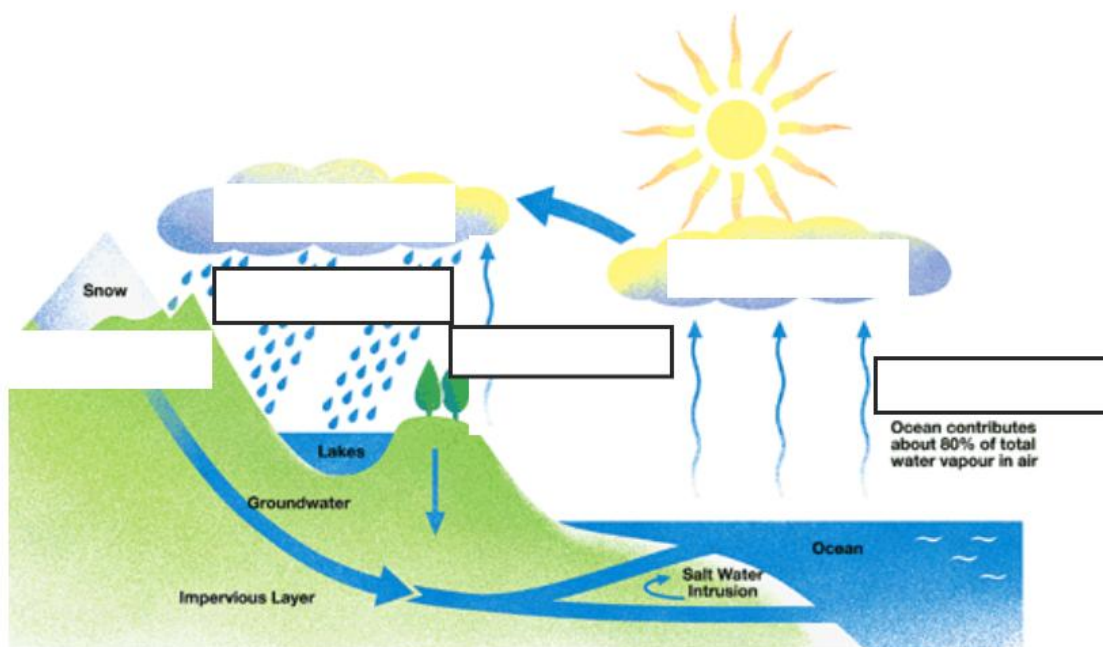
Appendix A— Concept Map for Solar Energy Travel



Appendix B—Compare and Contrast Matrix for Heat Transfer

	1. Radiation	2. Conduction	3. Convection
How it works			
An example of how heat is transferred in this process			

Appendix C—Water Cycle Diagram



Appendix D—Student Interview Comments

Interviews were conducted in a whole group setting. Students presented their opinions of graphic organizers orally.

Supporters of Graphic Organizers		Supporters of Traditional Note-taking/ Anti-Graphic Organizers	
3-Kathryn	Notes lose your ideas easier	1-Zach	You can write what you want with notes
5-Casey	You need to write your notes in a way that you understand	2-Ryan B.	You can put notes into your own separate categories
6-Erin	You have to think about too many bullets with notes	4-Jackson	Disagrees with Kathryn
7-Caleb	Graphic organizers helped me learn because notes have more information; graphic organizers are just easier	10-Jackson	I like to have more information, and more freedom and room to write what I want
8-Laura	Graphic organizers helped me on the test because they showed me what things meant	13-Jake	Graphic organizers didn't help me; I didn't like it
9-Georgie	Graphic organizers are neater and it's easier to find information to study before the test	14-Lauren	No help
11-Erin	Graphic organizers have focused questions and answers and pictures to remember them	18-Steven	No, there was too much work with filling it in
12-Ryan F.	Graphic organizers are neater and they actually answer questions; it's easier because notes are just memorizing and the graphic organizers showed what things meant compared to each other		
15-Nick	Graphic organizers had a focus and helped me study		
16-Sydney	Graphic organizers are neat and clear		
17-Nicole	They made me remember		
19-Kyle	They helped organize my thoughts		
20-Andrew	Me too		

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