Concept Maps and Informational Read-Alouds: Strengthening both Science and Reading for Elementary Students

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Abstract

This quasi-experimental study compared the effects of concept mapping and teacher generated questioning on students' organization and retention of science knowledge when used along with interactive informational read-alouds. Fifty-eight third grade students completed an eight-day unit regarding "soil formation." Students who participated in concept mapping scored significantly higher on a test of relational vocabulary, identification of key ideas and written expression than students who participated in traditional teacher questioning.

Proficient skills in science and reading are prerequisites to be productive members of society. Individuals must be able to use scientific processes in everyday decision-making and must possess the scientific background knowledge to make sound decisions (National Science Standards [NSS], 1996). In addition, individuals must have the literacy tools to read and comprehend informational articles about current scientific topics that affect their lives (e.g. salmonella, cancer research) (Draper, 2011). Moreover, many individuals will have roles in society that require science and literacy skills including teachers, engineers, scientists, and researchers (National Standards, 1996). However, current instructional practices, in which reading and content instruction are typically separated, often leave students unable to handle the more challenging demands of content material (Shanahan & Shanahan, 2008).

Fortunately, there have been promising instructional practices shown to benefit science and reading instruction including:

- integrating science and literacy (Pearson, Moje & Greenleaf, 2010);
- incorporating informational text (using science trade books (Smolkin, McTigue, Donovan & Coleman, 2008);
- using informational interactive read-alouds (Smolkin & Donovan, 2001);
- the use of graphic organizers specifically concept maps (Oliver, 2009);
- and teacher questioning (Heilman, Blair & Rupley, 2002).

But little or no research has combined these methods to examine its effect on student learning. The present study examined how the use of interactive read-alouds using science trade books with concept mapping and/or questioning affected elementary students' organization and retention of *different types of science knowledge*.

Integration of Science and Literacy is Not a New Concept

The integration of reading and science is not a new concept. In fact, scientists have integrated the two for centuries (Pearson, Moje, Greenleaf, 2010). To help students to experience science in its true state, then teachers must provide a learning environment that promotes the integration of science and literacy.

With the explosion of scientific information from salmonella illnesses (Draper, 2011) to cloning (Rupley & Slough 2011), there has never been such a crucial time for one to be a "scientifically literate citizen" (Fang & Wei, 2010).

The National Science Education Standards define science literacy as the following:

> Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of the sources and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (NSS, 1996, pp. 2).

As evidenced above, a key factor in the preceding definition is the need for literacy skills. One must be able to read and most importantly understand text, articles, and journals to learn about scientific phenomena. Scientific literacy also implies that one must be able to write and communicate effectively to make informed decisions. Accordingly, researchers have suggested that literacy is an integral part of learning science (Shanahan & Shanahan, 2008).

The Importance of Incorporating Informational Text

Incorporating informational text is not an option but a necessity for teachers. By the time students reach sixth grade, 75% of their reading will be from informational texts (Moss, 2005). In addition, many of their assessments by grade four will require them to understand and comprehend informational text. For example, 50% of the fourth grade National Assessment of Educational Progress, (NAEP) contained informational text (Moss, 2005).

It is evident that students need early exposure to informational text to help them prepare for later grade levels and the expectations of the College and Career Readiness Standards. Duke (2000) brought awareness to the educational community about the importance of informational text as well as the scarcity of informational text in the primary grades. In her landmark study that shed light on the use of instructional text in the primary grades, she investigated the time spent with informational text and found only 3.6 minutes was the average time spent per day on this genre. Jeong, Gaffney & Choi (2010) extended Duke's study with grades 2-4. They found consistent results with one minute spent on instructional text in grade 1 with an increase to only 16 minutes in grades 3 and 4.

It has been suggested that the scarcity of informational text may be associated with the decline in reading achievement after third grade (Chall, Jacobs & Baldwin, 1990; Ness, 2011;). This decline has also been referred to as the "fourth-grade slump" (Jeong, Gaffney, Choi, 2010). Around fourth grade, there is an increase of informational text. Some fourth graders are unprepared to comprehend this informational text and, therefore, experience a decrease in reading achievement (Ness, 2011). With this evidence, there is an even stronger need for primary teachers to incorporate informational text in their curriculum.

Instructional Strategies Used in this Study

Informational Interactive Read-Alouds

Reading aloud in both homes and classrooms is a widespread practice (Beck & McKeown, 2001) that has shown to be beneficial to learning (Morrison & Wlodarczyk, 2009). The report *Becoming a Nation of Readers* (Anderson, Hiebert, Wilkinson, & Scott, 1985) concluded that "the single most important activity for building the knowledge required for eventual success in reading is reading aloud to children" (p. 33). Recently, there has been an increase in intentionally and purposefully combining reading aloud of informational texts with guided conversation or discussion, also referred to as "informational interactive read-alouds".

An informational interactive read-aloud is a multifaceted instructional technique in which a teacher models reading thought processes while engaging students in discussion through sharing and posing questions (Beck & McKeown, 2001; Smolkin & Donovan, 2003;). When modeling, teachers "think aloud" to reveal reading strategies that proficient readers use in reading and understanding informational text including "fix up" strategies when comprehension breaks down (Loxterman, Beck, McKeown, 1994). These metacognitive strategies are essential to learning because they allow learners to assess their own level of comprehension and adjust strategies as needed (Oster, 2001).

Another critical component of interactive read-alouds is the facilitation of dialogic discussion encouraging students to participate in a collaborative discussion (Reznitskaya, 2012). As opposed to traditional read-alouds in which the teacher has sole authority, a dialogic discussion is unique because authority is shared among the students and the teacher encouraging students to discuss pose questions share their ideas and examine others' viewpoints regarding the text (Reznitskaya, 2012). In addition, students are provided an opportunity to make connections with the text. Through this cognitive process, a student makes a connection to self, other texts, or to the world (Harvey & Goudvis, 2007). Text may have different meanings for different individuals because each reader brings his or her own background knowledge and personal experiences that shape the meaning of the text (Rosenblatt, 1978). Rosenblatt (1978) proposed a "transactional view" of reading in which the reader transacts with the text to make meaning (Morrison & Wlodarcyzk, 2009; Rosenblatt, 1978). Not only do students have an opportunity to discuss and deepen their understanding of complex science concepts, discussion provides a platform for minimizing students' misconceptions (through teachers' assessment) and increasing vocabulary development (Leung, 2008).

Graphic Organizers and Concept Mapping

Graphic organizers are a literacy strategy tool shown to benefit students in learning content (Katayama & Robinson, 2000). By organizing information and showing relationships between concepts through the use of arrows, lines and text boxes, graphic organizers aid students in learning from text in multiple ways (Hall, Kent, McCully, Davis & Wanzek, 2013). The visual structure helps students organize information and make relevant connections (Katayama & Robinson, 2000). Translating information from a text format to a graphic organizer can deepen the learning process for the reader (Nesbit & Adesope, 2006).

This study focused on the use of the *concept map*, created by Novak (1990) as a tool to help students organize ideas and thoughts especially in the area of science. In using a concept map, a teacher or student selects a certain topic to be mapped (Novak & Gowin, 1984). As shown in Figure 1, the students have an opportunity to identify key concepts and then draw lines to connect and show relationships between concepts. Linking words or phrases are used to define these connections. A particular advantage to concept mapping is that it can be used as a pre-reading, during reading and/or a post-reading activity.

Teacher Questioning

A common and very traditional approach to teaching and learning is teacher-generated questioning which has proven to have positive effects on students' text comprehension (2007; Feldt, Feldt, & Kilburg, 2002). Among the benefits is the promotion of student understanding by focusing attention of the important details. In addition, this instructional strategy can be beneficial in clarifying meaning as well as minimizing students' misinterpretation of information (Heilman, Blair & Rupley, 2002). Questioning can also aid in propelling prior knowledge by activating students' experiential and conceptual backgrounds (Heilman et, al., 2002) promoting deep processing of information (McKeown & Beck, 1993).

But yet, there have been several criticisms to using teacher questioning as an instructional method (Feldt, et al., 2002). First, students may search for important ideas to memorize instead of making connections and increasing relational knowledge (Cook & Mayer, 1983). Secondly, some of the questions that may be used, especially publisher-provided, fail to promote higher cognitive levels (Feldt, et al., 2002). Although effective teacher questioning has also been shown to promote students' understanding (Heisey & Kucan, 2010; Lloyd, 2004), most questions are not designed to promote connections between ideas in the same manner as concept mapping.

Methodology

Participants

The participants were third grade students from an urban elementary school in the northwest region of the United States. There were 29 participants in the treatment group and 29 participants in the comparison group. Both groups participated in an eight-day study over the scientific topic of soil formation.

Both groups participated in an informational interactive read-aloud. The students in the treatment group participated in a concept mapping activity while participants in the comparison group participated in a teacher-questioning activity. Both activities were conducted before and after the informational interactive read-aloud.

Treatment Group: Concept Mapping

Used as a pre-reading activity and to assess prior knowledge, participants in the treatment group created a concept map on what they already knew about the concept being taught for the day (e.g. soil formation). Then students had an opportunity to share their concept map with their classmates, followed by the creation of a class constructed concept map. As a post-reading activity, students created another concept map as shown in Figure 2 on what they learned during the lesson, again followed by an opportunity to share their map with their classmates.

Comparison Group: Teacher Questioning

Since teacher questioning is commonly used in traditional teaching, it was the strategy used for the comparison group. As a pre-reading strategy and to assess prior knowledge, the teacher posed several questions in regards to the topic being discussed for the day (e.g. soil formation). For example, one of the questions posed by the teacher on the first day of the lesson was "What do you know about soil?" Students had an opportunity to write down their answers and share their responses with the classmates. The teacher posted the students' answers on the board. As a post-reading activity, the teacher posed questions regarding the lesson. For example one of the questions posed by the teacher was “What is the purpose of soil?” Students had an opportunity to write down their answers followed by an opportunity to share their responses with the class as is a common classroom practice.

Both Groups: Informational Interactive Read-Aloud

Participants in both the treatment and the comparison group participated in a series of informational interactive read-alouds conducted by the science teacher. The teacher used a science trade book focusing on the specific concept they were learning for that day. The trade books were selected by a group of third grade teachers based on content accuracy and aesthetic appeal. During the informational interactive read-aloud, the science teacher modeled her reading process while engaging students in dialogic discussion regarding the scientific text.

Assessments

Pre-test, post-test and delayed post-test were developed by the researchers. Information about the concept of soil formation was measured using the following types of assessments:

a) relational vocabulary assessment (measuring relational knowledge);
b) vocabulary matching assessment (measuring individual word knowledge);
c) multiple-choice comprehension assessment (measuring students' ability to identify key ideas; and
d) a writing comprehension assessment (measuring students' clarity of written expression).

The relational vocabulary assessment required students to find the underlying similarity between a set of concepts whereas the matching vocabulary test relied on simple definitions. The pre-test was administered a week before the study. The post-test was completed the day after the study was completed and the delayed post-test was administered five days after the completion of the instructional unit.

Data Analysis

Analysis indicated that the treatment and comparison group performed comparable on the pre-test indicating that there was not a significant difference between the background knowledge of participants in both groups. As shown in Table 2 located at the end of the article, the treatment group scored significantly higher than the comparison group on the post-and delayed post-tests on three of the four assessments including relational vocabulary (measuring relational knowledge), multiple choice (measuring ability to identify key ideas), and the writing assessment (measuring clarity of written expression). These findings appear to be quite logical due to the goals cognitive strategies involved in completing concept mapping procedures. Surprisingly, there was not a significant difference in the performance of the treatment group and comparison group on matching vocabulary.

It is also important to highlight that although the treatment group outperformed the comparison group, both groups showed significant growth.

As shown in Table 3 located at the end of the article, the treatment group showed significant growth between the pre-test and post-test on all four assessments specifically in relational knowledge (as measured by the relational vocabulary assessment), ability to identify key ideas (as measured by the multiple choice assessment), clarity of written expression and use domain knowledge (as measured by the writing assessment), and individual word knowledge (as measured by the vocabulary matching assessment). In addition, there was not a significant difference between their performance on the post-test and on the delayed post-test (given five days later) on all four assessments.

As shown in Table 4 located at the end of the article, the comparison group showed significant growth between the pre-test and post-test on all four assessments. It is important to note that there was not a significant difference between their performance on the post-test and delayed post-test on the writing assessment. However, there was a significant difference on the relational vocabulary assessment, multiple-choice assessment and matching vocabulary assessment. This indicates that participants in the comparison group were able to retain information in written expression but not in relational vocabulary knowledge, identifying key ideas and individual word knowledge. Data analysis of the specific types of science knowledge assessed is highlighted in the next sections.

Discussion of Results

Relational Knowledge

Relational knowledge is being able to identify relationships between concepts as well as how they are related (DiCecco & Gleason, 2002). Based on constructivist ideas, Novak designed the concept map as a tool to show students' understanding and meaning of concepts in their own cognitive structure (Novak & Gowin, 1984). Concept maps have been shown to be beneficial due to its visuospatial elements. It is logical then, that students who used concept mapping increased their relational knowledge. This graphical instructional tool features *cross-links* that highlight relationships or links between concepts in different domains of the concept map, signaling hierarchical relationships (or other types of relationships) that can be immediately perceived by the student (Novak & Canas, 2006).

Recall of Key Ideas

The data also revealed that concept mapping was beneficial in helping students recall key ideas as measured by a multiple-choice assessment. This finding is consistent with dual coding theory suggesting that storing information in two codes, verbal and nonverbal (e.g., visual), may aid in increasing memory or recall of information because it provides two pathways to retrieve it from long-term memory (Paivio, 1986; Paivio & Csapo, 1973; Sadoski, 2005; Vekiri, 2002). Dual coding theory can be applied to concept mapping because the graphical organizers uses visual graphics (shapes) as well as text proving advantageous for memory.

Written Expression

The students in this study using concept mapping scored higher on tests of written expression. This is consistent with findings from DiCecco and Gleason (2002) who found that students who used graphic organizers for learning science also scored higher on written essays. One of the most critical processes in writing is the organization of ideas. According to Novak and Gowin (1984), graphic organizers such as concept maps are powerful pedagogical tools because they allow learners to visualize concepts as well as the hierarchical relationships between them which could result in clearly articulated and organized written essays. In summary, the use of graphic organizers, such as concepts maps, can be beneficial for students in the area of writing combining their ability to apply newly acquired knowledge as well as express their relational knowledge in a coherent essay.

Individual Word Learning

In addition to discussing the significant differences between the groups, it is equally critical to discuss areas in which they did not differ in performance. Specifically, there was not a significant difference between the treatment group and the comparison group on individual word learning, as measured by the matching vocabulary assessment. Of interest, in the analysis of graphic organizer research, few studies have used the matching format as an assessment. This may be due to the fact that the type of learning theoretically promoted by concept maps (relationships) (Novak & Canas, 2006), is not easily captured by such a format. Therefore, there may be other literacy instructional methods that might be more beneficial for individual word learning.

Retaining Information

Finally, an important feature in this experimental design was the use of immediate and delayed post-testing. The treatment group's gains in relational vocabulary, identifying key ideas, and written expression were maintained after five days as measured in the delayed testing indicating that concept mapping facilitates learning as well as supports the retention of the information. According to Robinson (1998), one of the limitations in past research on graphic organizers is the limited use of assessing students in a delayed measurement. However, to measure long term learning, delayed measures are more important than immediate recall.

As expected, all groups performed lower in the delayed post-test than the immediate post-tests. However, the amount of loss differed between the treatment group and comparison group. On all of the four assessments, the treatment group had a lower point decrease in the mean average between the time-points of the post-test and the delayed post-test indicating that the treatment group demonstrated higher retention than the comparison group.

Limitations

The study had several limitations that might have affected the statistical outcome of the data. A longer treatment period would provide students with more opportunities to further develop their skills associated with the use of concept mapping with additional topics and concepts in science. It would also be interesting to see if levels of differences between the treatment group and the comparison group would increase, decrease or sustain. Next, it would have been ideal if there were a longer period between the post-test and delayed post-test. However, due to constraints of the school calendar, there was only five days between the post-test and delayed post-test. It would have been ideal if there were a longer period between the post-test and delayed post-test.

Implications

While moderate in scale, the results of this study indicated that concept mapping coupled with interactive informational read-alouds could be an effective strategy in learning science concepts. The treatment group scored higher on three of the four assessments. This finding indicates that concept mapping may be suited to promote certain types of knowledge including identifying key ideas, recalling information and written expression. The use of concept mapping did not take more time than answering comprehension questions, but was more effective on three of four assessments, in both immediate and delayed post-testing. Using concept maps with a set of related texts, or text set facilitated students' connections across texts and focus on the underlying science concepts. Additionally, the discourse and interaction between students when creating the concept maps may have been a rich source of learning.

Technology Applications

The beauty about concept mapping is that it can be done before, during and after reading. In addition, concept mapping can be incorporated into all content areas. Recently, there has been a plethora of new technology applications featuring graphic organizers. In fact, these applications have opened the door for collaborative opportunities providing a platform for students to work on their project in real-time in partners or even groups. We have highlighted several applications in Table 5 located at the end of the article. Figure 1 is an example of a concept map using Bubbl.us. Not only will this increase their technology skills in this Digital Age, it will increase their knowledge in learning science concepts.

Figure 1. Example of Concept Map

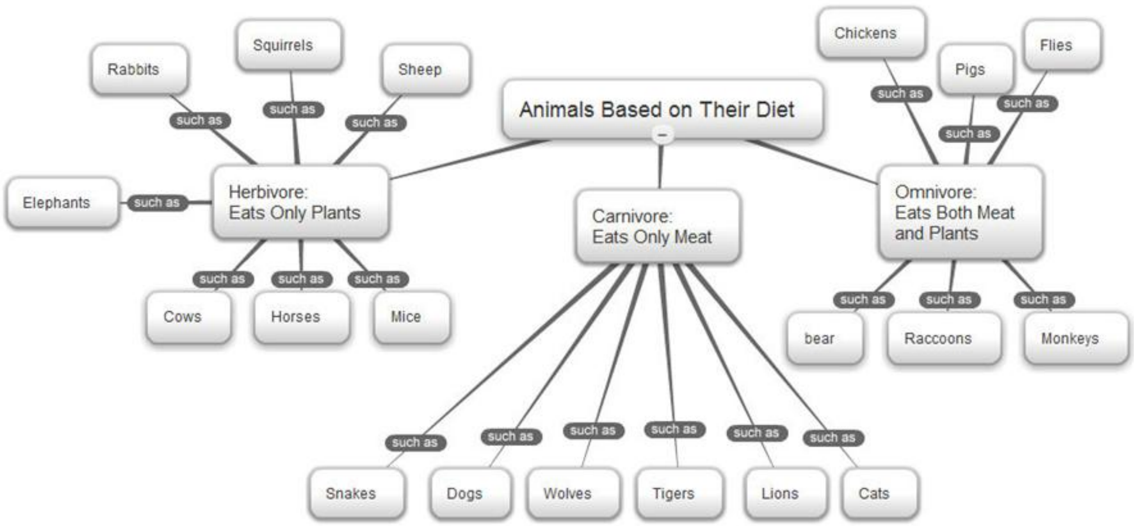

Figure 2. Student's Concept Map on Soil

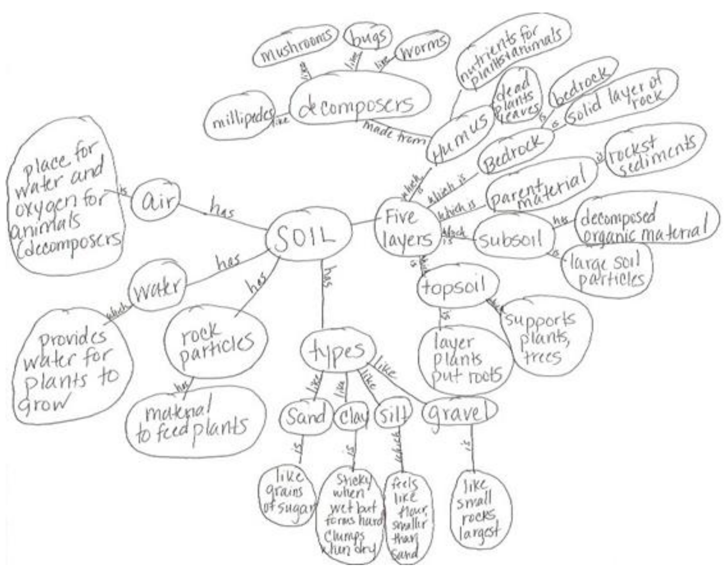

Table 1: Science Trade Books Used for Informational Interactive Read-alouds

Title & Author	Topic Content
Sand and Soil: Earth's Building Blocks Beth Gurney	In this book, Gurney provides an overview of soil including the composition of soil and types of soil layers.
Without Soil Ashley Chase Marco Bravo	In *Without Soil*, Chase and Bravo discuss the importance of soil.
Dirt Nancy Goodman	In this text, Goodman discusses sand, silt, erosion and humus. The book provides a glossary, hands-on activities and fun facts.
Soil Erosion and How to Prevent It Natalie Hyde	Hyde helps students understand the impact of erosion on real life. The author describes the processes of weathering, erosion, and deposition. It also provides ways to prevent erosion.
Erosion Becky Olien	In *Erosion*, Olien discusses the different types of erosions. Natural landmarks are used as examples. The author also discusses how to help fight erosion.
Minerals Rebecca Faulkner	In this book, Faulkner explains how minerals form. The author also discusses the types of minerals
Wiggling Worms at Work Wendy Pfeffer	An addition to a popular science series explores how the cycle of life is enriched by the way worms live, eat, and work in the underground environment
Composting: Nature's Recyclers Michael Koontz	As an overview of composting, Koontz describes how a compost heap works, what it needs to work well, and what plants, insects, and bacteria help to break down the organic refuse found in one.

Table 2: Comparison of the Performance of the Treatment and Comparison Group

Test	Group	Pre-Test			Post-Test			Delayed Post-Test		
		M	SD	ρ	M	SD	ρ	M	SD	ρ
RV	Treatment	9.31	6.50	.676	93.80	9.03	.001	88.97	7.24	<.001
	Comparison	10.00	5.98		82.76	14.12		77.24	11.30	
MC	Treatment	43.79	13.47	.925	90.00	10.00	.001	86.20	11.15	<.001
	Comparison	43.48	14.21		78.87	13.98		71.04	16.11	
WA	Treatment	24.14	8.14	.326	76.72	17.59	.001	74.14	17.01	<.001
	Comparison	25.86	4.64		62.93	25.55		54.31	24.15	
MV	Treatment	17.59	13.54	.854	84.14	13.50	.295	81.03	14.23	.082
	Comparison	18.28	14.90		79.66	18.42		73.45	18.18	

Note. RV=Relational Vocabulary. MC=Multiple-Choice. WA=Writing Assessment. MV=Matching Vocabulary.

Table 3: Growth of Performance for the Treatment Group

	Pre-Test	Post-Test	ρ	Delayed Post-Test	ρ
Relational Vocabulary	9.31	93.80	<.001	88.97	.002
Multiple-Choice	43.79	90.00	<.001	86.20	.008
Written Assessment	24.14	76.72	<.001	74.14	.795
Matching Vocabulary	17.59	84.14	<.001	81.03	.158

Table 4: Growth of Performance for the Comparison Group

	Pre-Test	Post-Test	P	Delayed Post-Test	ρ
Relational Vocabulary	10.00	82.76	<.001	77.24	<.001
Multiple-Choice	43.48	78.97	<.001	71.04	<.001
Written Assessment	25.86	62.93	<.001	54.31	.023
Matching Vocabulary	18.28	79.66	<.001	73.45	<.001

Table 5: Suggested Applications for Concept Mapping

Technology Application	Features
Popplet (http://popplet.com)	Popplet allows students to display ideas using graphic organizers (concept maps, timelines). This is a great tool for students to help them organize science concepts. Want to increase collaboration in your classroom? Using Popplet, students can collaborate in real-time opening up a world of teamwork possibilities.
Bubbl.us (https://bubbl.us)	Very similar to Popplet, Bubbl.us(https://bubbl.us) also has the capability of creating and sharing graphic organizers with others. A neat feature in Bubbl.us is that students can also export their graphic organizers in Powerpoints and other type of documents. Bubbl.us also features a plethora of types of graphic organizers in different shapes and colors that will spark your students' interest.
Educreations (http://www.educreations.com)	Though not specifically a graphic organizer tool, Educreations is an interactive whiteboard providing an opportunity for students to create a variety of organization tools such as concept maps. Students will love this versatile application because it offers endless possibilities.

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