TEACHING READING STRATEGIES IN THE SCIENCE CLASS

The Effect of Teaching Reading Strategies on Comprehension in the Science Classroom

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Abstract

Science texts require students to use new skills to be effective readers. It has not been the practice of the science department at Nordhoff High School to spend much energy teaching these skills. This study examined the effect of teaching a reading strategy on student comprehension. Students were taught to use graphic organizers as a reading tool. The effect of this was assessed with post-read quizzes, interviews, and unit tests. Findings demonstrated an increase in test scores. Interviews show that students find graphic organizers are improving comprehension, but too time consuming. Using graphic organizers has demonstrated itself to be a valuable teaching strategy, but may need much reinforcement to prevent students taking shortcuts. A study over a longer term may see if students take ownership of this strategy.
The Effect of Teaching Reading Strategies on Comprehension in the Science Classroom

Standardized test scores for students at Nordhoff High School demonstrate a need to improve students’ skills in contextual reading (Accountability Report, 2006). The current WASC report for the school identifies improving reading skills as an area of critical need (WASC, 2003). As a school, some departments have addressed this better than others. Although there is not one uniform strategy, most members of the social studies department have structured strategies for pre-reading exercises (front loading vocabulary, group discussions) as well as enhancing reading comprehension (note taking skills, graphic organizers, identifying major ideas or themes, and recognizing the point of view of the author) (Hoj, 2005). Unfortunately, there is little use of such strategies in the science classes at Nordhoff High School. Some of the teachers use the texts as merely a source of problems to use for assignments. Others assume their students have the ability to effectively read and comprehend the text information without any prior instruction or modeling. What results, in my opinion, is an inability of the students to effectively gather information from a text and apply that information to new situations.

My observations lead me to the conclusion that many, if not most students in science classes rely nearly entirely on the notes they take, and the knowledge they gain from labs and activities. My assumption, when assigning homework, is that students will use the text to increase their understanding of the concepts being covered. If students are not reading or not understanding what they read, then it is more likely that they will not complete the assignment, do what they can from their prior knowledge, or copy from someone who did complete the assignment. None of these possibilities will produce increased understanding. It is possible that misconceptions could be reinforced.
Purpose

The purpose of this study was to examine the effects of teaching reading strategies on the students’ comprehension of the content in my biology classes.

The specific research question is:

- If specific reading strategies are taught, will students demonstrate an increase in their comprehension of the reading assigned?

Importance of the Study

Recent texts on reading across the curriculum make it clear that there is great value in using such strategies in the science classroom (Vacca & Vacca, 1986) (Fischer, Frey & Williams, 2002). I would assume that many teachers already use these kinds of strategies, so the value to some veteran teachers may be simply to verify the validity of using them. It is likely that there are still many science instructors who do not address issues of literacy in their classes in any direct way. If the Science Department at our school is any gauge, there may be less reading instruction happening in science classes.

The information gathered by this project will be valuable to the Science Department at Nordhoff. In my observations of my peers, I can only find examples of pre-reading exercises, and only with the basic level classes. Those are limited to frontloading vocabulary, and are somewhat unstructured and inconsistent in their implementation. Discussions with our Chemistry instructors has revealed that, without the instructor telling the students what the text says, students seem unable, or possibly unwilling to decipher the meaning of the text on their own. If outcomes of this project demonstrate better performance in our students when more attention is placed on how our students read, then this may lead to curriculum changes throughout the department. This
has the potential of improving the performance of our students in their science learning. A change in department policy may also lead to an improvement on reading scores on standardized tests dealing with informational reading.

The greatest and most immediate value to this project is the information that I gain about my classes. The results of this project will help me be more effective in meeting the needs of my students. If students show an increase in comprehension when using specific reading strategies, then I would develop this into my regular curriculum, giving my students another valuable learning tool.

Review of the Literature

*Effective Readers*

Expository texts, such as those commonly found in high school math, science, or social science courses requires a far different set of skills than what these students have used in most of their reading in the past. Students must make the shift from learning to read to reading to learn (Barton, 1997), (Bryant, et al, 1999). Students may be well prepared to read a narrative. They have a set of expectations about something that follows a story line. Without guidance, they do not have similar expectations for expository texts. If there is not an effective strategy to acquire information from the text, then the student flounders (Rhoder, 2002), (Slater & Horstman, 2002), (Bryant, et al, 1999). Subject area teachers, faced with this dilemma, tend to give students the information they need to know in lecture settings (Billmeyer, 1996), (Barton, 1997). With an increased emphasis in comprehension of expository text on standardized tests, and a higher demand for reading skills in the workforce, it is important that students develop the skills necessary to become effective readers (Barton, 1997).
The question that must be answered first is what makes an effective reader. There are a variety of outlines that have been made of this in the literature. I will summarize from those lists below.

An effective reader:

- Accesses prior knowledge.
- Has a purpose for reading.
- Identifies the main ideas and can pick out what is important in a passage.
-Clarifies vocabulary and confusing parts of text.
-Asks questions.
-Reflects on how the reading relates to prior knowledge, other concepts, the reader.
-Understands the organization of the text.

Compiled from (Slater & Horstman, 2002), (Barton, 1997), (Rose, 2000)

*Science Texts*

Science texts in particular offer greater challenges than other texts. They can include more new vocabulary than a student learns in a foreign language class. The text style may make it more difficult to identify the main ideas. Authors of science texts tend to infer relationships of concepts without using the cue words found in other texts, such as ‘first’, ‘moreover’ (Barton, Heidma, & Jordon, 2002). These issues further complicate the ability of the student to gain comprehension and increase the need for teaching the students skills to master their texts.

David Donahue (2000) describes science readers as “interactive information processors who switch between selective perceptions of texts and concurrent experiences
such as experiments and discussions.” He suggests that science reading should be as interactive as a lab experiment. So the challenge to teachers is to make reading an involved, active, and interactive exercise.

**Strategies to Improve Reading Comprehension**

There are many variations on what strategies to use, but they all distill down to a similar pattern.

*Pre-read.*

Before reading, it is usually recommended to have students access their prior knowledge. Vacca & Vacca (1986) identify this of being of particular importance (p 15). Of the many ways of doing this, there are two that seemed interesting. Anticipation guides give the students four to six true false questions to answer before and after they read (Barton, et al, 2002), (Barton, 1997). Variations on this call for written justification for their answers and support from the reading. Another is a KWL chart, which requires the reader to write what they already **know**, what they **want** to know, and, after they read, what they **learned** (Fisher, Frey, & Williams, 2002).

The importance of vocabulary instruction is also well documented. The danger here is that looking up words in the dictionary is universally considered ineffective. It is better that students learn words within their context, or derive meaning from root words, prefixes, and suffixes (Bryant, et al, 1999), (Vacca & Vacca, 1986), (Barton, et al, 2002), (Fisher, et al, 2002) (Armbruster, & Nagy, 1992).

*Read.*

During reading, it is important that students are able to decode the text style to find the main ideas and extract meaning. This must be modeled in the classroom (Barton,
et al, 2002). Another strategy that is recommended is reciprocal reading. Students work in small groups to pose questions, make predictions, summarize, clarify what they have read. This would also have to be started as a teacher moderated activity until the students are able to moderate their own groups.

Due to the concepts taught in science texts, graphic organizers are valuable tools to illustrate cause and effect, timeline, compare and contrast relationships (Bryant, et al, 1999), (Barton, et al, 2002), (Vacca & Vacca, 1986), (Rhoder, 2002), (Fisher, et al, 2002). Organizers allow students to visualize relationships or processes. When students use organizers, they are identifying main ideas, asking questions, and making connections to prior knowledge. They are thinking about what they are reading.

A combined set of strategies, labeled EMPOWER, really involves many of the skills already listed. It combines accessing prior knowledge, monitoring comprehension, posing questions, sorting questions into categories, developing a web of information from the reading, connecting question categories to web, and reflection (Linek, 1996).

The use of structured note taking, such as Cornell notes can give room for students to write down questions, unknown vocabulary and summarize what they read (Fisher, et al, 2002). Cornell notes also forces students to go over the notes to learn what was learned and what needs more clarification.

Whatever strategies are used it is strongly suggested that they be modeled in a setting that ensures success so that students will be able to see the value (Rhoder, 2002). Another recommendation by the same author is to add a few strategies at a time. It is not effective to suddenly expect the students to use six or seven different skills. The intent must be for the students to build a set of skills that they will use independently.
Needs at Nordhoff

Statistics on standardized test scores demonstrate that students at Nordhoff High School are not performing as well as they should in contextual reading. Results on state tests in 2001 and 2002 reveal 50% of students are above the 50th National Percentile Rank (Accountability Report, 2006). These rankings are 20% below the rankings for math during the same years. The same report reveals only 51% of sophomores were proficient or advanced on the STAR tests in the 2003 and 2004 school years. These results are far below what is expected for our students. These results were the focus of our WASC accreditation report, in which, improving content area reading is listed as an area of critical need (WASC, 2003). Action plans in that report emphasize the development of plans in each department to address this need. Although this emphasis has been replaced with standards recently, the need to address content area reading still exists.

The use of reading strategies has been limited in my classroom, which gives me the opportunity to explore the effect of such practices on my students. Considering the limited time available for this study, and considering that the literature suggests introducing one new skill at a time, I chose to have my students learn and use one strategy during this study. I selected the use of graphic organizers as the strategy to study. Graphic organizers or something like them are an integral part of many of the reading programs listed in the literature. They build a variety of good reading skills. If results show that using graphic organizers is effective for my students, I could add other facets in the future and test their effectiveness.
**Action Research**

A comparative action research was conducted using students in four of my classes to test any difference in comprehension caused by the teaching and use of graphic organizers as a reading skill.

Action research empowers the practitioner to make informed decisions about instructional practice (Glanz, 1998), (Gall, Gall, & Borg, 2004). Instead of more formal scientific research, action research is carried out by the people who have to enact change based on its results. It is research in a real world setting, where experimental control may be difficult or impossible. Although quantitative results are analyzed, action research is more qualitative. There is less emphasis on statistics than more formal scientific research. Due to its focus on a single real world setting, the results do not lend themselves to broad generalizations. They give the researcher information about a teaching practice in one setting under one set of parameters (Glanz, 1998).

The effective teacher should be constantly evaluating what teaching practices best lead to the desired outcome in their students. Action research provides the information to make those decisions (McNernan, 1991), (Holly, Ahar, & Kasten, 2005). The way we teach and the strategies we use should be based on the curriculum at hand along with practical research (Steinhouse, 1975). Stephen Corey (1953), an early promoter of action research in education states “The studies must be undertaken by those who may have to change the way they do things”. Action research has been used in a variety of social settings since the early twentieth century. It has been used to inform change in such areas as health, industry and education. (McNernan, 1991), (Birman, Desimone, Porter, & Garet, 2000)
In the 1950’s, Stephen Corey was a strong advocate of action research in education. He felt strongly that using action research would effectively bring about meaningful change because the practitioners would be more likely to use the information gained by their own research. Due to its lack of empirical control and qualitative nature, action research fell out of favor in the 1960’s and was replaced by clinical research on education and learning. (McNernan, 1991), (Glanz, 1998)

Today, the teacher is seen as an investigator, constantly assessing and evaluating teaching practice. The ideal situation is now seen as one where a question brings about investigation, which provides evidence, which brings about change, which provides evidence for more change, and on and on (Holly, et al, 2005).

So what does action research do? It solves problems. It enhances the decision making process. It encourages teachers to reflect on their practice. It develops a positive attitude toward school change. It has a direct impact on teaching practice. It gives the power to improve to those who participate (Holly, et al, 2005), (Gall, et al, 2004) (Glanz, 1998).

Often, the data collected is qualitative. It can be in the form of interviews, samples of student work, case studies. These are often presented as written descriptions. Analysis is more inductive in nature. Observations can be compiled and quantified, but little or no statistics will be used (Johnson, 2002), (Glanz, 1998), (Gall, et al, 2004). More quantitative results could be in the form of comparative studies or correlation research.
Correlations would normally be studying the relationship between two variables. Comparative studies are used when studying a variable using an experimental and control group. Often this is done using quasi-experimental methods. Although this is much like
experimental design, it is different due to the lack of experimental control, a common problem in studies involving groups of people. There is not entirely random placing of people into groups, like classes in a school (Gall, et al, 2004), (Glanz, 1998), (Holly, et al, 2005).

In order to ensure the validity of any finding, it is important that there are a variety of evidences to support any claim. This provides a better chance that the results you observe are due to the variable being tested. Each question should have at least three different assessments to gather evidence. This is often known as triangulation. (Gall, et al, 2004), (McNernan, 1991), (Johnson, 2002).

Summary

Literature has shown that students require special skills to be effective readers of expository texts. Science texts in particular, can be challenging to read for students with no strategy to their reading. Recommended strategies before reading include using anticipation guides to access students prior knowledge, and the development of vocabulary. During reading, note taking or graphic organizers help students make connections. Reciprocal reading allows students the ability to develop skills in asking questions and making predictions. Reading programs often involve a combination of those skills, but it is recommended that the skills be taught and developed one or a few at a time.

Action research has been demonstrated to be an effective tool for educators to make informed decisions about curricular development and teaching strategies. The qualitative nature of action research is a valid mechanism for studying classroom situations, where controlling variables can be difficult or impossible.
Test scores at Nordhoff High School have demonstrated a need to address reading skills. It has not been my practice to have the teaching of reading skills be part of my curriculum. Based on the literature reviewed, I was interested to see what effect such a change in my teaching would have on my students’ performance. The action research presented here was intended to test if the use of graphic organizers during reading assignments in biology classes would increase student comprehension of the concepts presented in the reading.

Methodology

Participants

The subjects of this research were from four of my biology classes at Nordhoff High School during the 2005-06 school year. These were all college preparatory classes. The students were predominantly sophomores, with a few juniors and seniors. Class size was between twenty five and thirty two students. All students in each class participated in the comparison study. Six volunteers were selected from one class to participate in interviews. They were selected from those who turned in parent permission slips. The selection was based on English language arts scores on the STAR test the previous year. Two were selected from those who were at basic level, two were proficient, and two were advanced.

Nordhoff High School is located in Ojai, California. The community is predominantly middle income. Only about 18% of the students attending Nordhoff can be identified as economically disadvantaged (based on enrollment in free or reduced lunch program). The school population is predominantly white, with approximately 20% Hispanic or Latino and a small percentage of other ethnic groups.
Procedures

This study was conducted over a period of nine weeks beginning October 18, 2005 and ending December 18, 2005. Three units of study were the curricular focus. Prior to the beginning of this study, all students completed a survey to determine their reading practices.

Although there was no deliberate grouping of abilities into any class, period three and period four demonstrated slightly greater academic ability on average in the months prior to the study as compared to period two and period five. Because of this, as I divided my classes into experimental and control, I chose to divide period four and three so as not to create misleading results.

During the first unit, students from periods four and five were given instruction on using graphic organizers as part of their reading. This instruction included modeling by the instructor, in class samples, group work and critiques of graphic organizers. During the last two units these classes were assigned to use graphic organizers as they completed their reading assignments. The students’ assignment grade was based on their completion of the graphic organizers. The assessments listed below were then given to compare their comprehension with the control classes.

During the entire period of the study, periods two and three acted as the control group and did not use graphic organizers. When they were assigned reading, they answered review questions as part of their assignment. These classes were assigned the same reading passages and were given the same assessments as the two experimental classes.
Data collection took place over the course of the last two units. During each unit, a quiz was given the day after one of the reading assignments. This quiz was based strictly on material from the reading. Six students selected from period four were interviewed after the first quiz. They were asked to evaluate the effectiveness of graphic organizers as compared to the strategies they normally use. They discussed the strengths and weaknesses of using graphic organizers as a reading skill. At the end of each unit, the unit test included a section of questions pertaining to a topic only covered by the reading assignments. The results of the quiz and the specific questions on the unit test were used to gauge the level of comprehension the students had acquired.

Materials

The textbook used in this study was *Biology* by Miller and Levine (2004). The chapters used were chapter 9 (cellular respiration), chapter 10, (cell growth and division) and chapter 11 (introduction to genetics).

Four measuring devices were used in this study.

- A survey, given to all students at the beginning of the project asked students to relate their common reading practices and the value they place on science texts in their learning. A copy of this survey is in the appendix.
- Two post-read quizzes were administered immediately (the day after) a reading assignment. Each quiz was composed of questions designed for students to demonstrate their understanding of the concepts presented in the reading. Copies of both quizzes are in the appendix.
- Six volunteers were interviewed after the first of the two quizzes. They were asked to assess if using graphic organizers helped them. They were asked to
discuss their usual reading practice, and evaluate the positive and negative aspects to using graphic organizers. Their responses were recorded and presented in the findings.

- Selected questions on the cell division and genetics unit tests were written from material that was only presented from reading assignments. The intent of selecting just specific questions was to eliminate the possibility that test results would reflect learning from labs, activities, or projects in class. These questions are presented in the appendix.

**Analysis**

The survey was analyzed inductively. Results of multiple choice selections were be totaled in order to better see trends. Free responses were grouped into similar categories and then quantified. The data was presented in the form of bar graphs. The intent was to see what were the students’ perceptions and practice in regards to expository reading. Also I intended to discover what strategies they were required to use in other classes. If my students already are in the habit of using effective reading strategies, then I would expect less difference in test results.

Results on both quiz and test scores were totaled for both the experimental classes and the control classes. Mean scores for each group were calculated and t-tests were conducted to look for significant difference between the two groups.

Interview results were transcribed and are presented in tact in the findings. They were used to compare the student impressions of the effectiveness of using graphic organizers with the test results.
Findings

The specific research question is:

- If specific reading strategies are taught, will students demonstrate an increase in their comprehension of the reading assigned?

The specific areas of evidence were:

- Student survey of reading practices.
- Two post-read quizzes.
- Responses from six student interviews.
- Specific questions from two unit tests.

*Student Survey*

The intent of the survey was to establish what normal practice was for my students when it came to reading texts, and to find what they are using in other classes. I expected students to select one answer for the multiple choice answers. Some selected more than one. I tabulated all responses, since it was difficult to interpret the meaning behind the multiple answers. The results to question 1 are in Table 1 and the graph in figure 1. Half of the students said that the text was often or always a valuable tool, while 15% said that it was of no help most or all of the time. These results are more telling when compared to question two, which asked them how they use their text when an assignment is given (see table 2 and figure 2). The most common response here at 44% is that students read only the material that they see as necessary to answer the question. Only 36% said that they would read the entire passage. A little over a third of the class are the only ones who are using the entire content of the text to gain understanding of the
material. A further 19% chose response four through seven, which range from using only the glossary or pictures to not using the text at all.

<table>
<thead>
<tr>
<th>Response</th>
<th>number of responses</th>
<th>percent of total</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>13%</td>
<td>always a great help</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>37%</td>
<td>often valuable</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td>37%</td>
<td>helpful about 50% of the time</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>11%</td>
<td>occasionally useful, but often no help</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>3%</td>
<td>I never find science texts useful</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1%</td>
<td>I never use science texts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>104</td>
</tr>
</tbody>
</table>

Question three asked students how much they rely on their text as a study tool for tests. The most common response was that the text is used equally with notes and other resources. Nearly a quarter of the students replied that they rarely or never use their text to study for tests.
### Table 2: Results of survey question 2

<table>
<thead>
<tr>
<th>response</th>
<th>number of responses</th>
<th>percent of total</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>9%</td>
<td>I read the passage completely, then attempt to answer the questions.</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>27%</td>
<td>I review the questions first, then read the passage completely</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>44%</td>
<td>I search for the part of the passage that deals with the questions and only read that.</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>3%</td>
<td>I look at the pictures and diagrams and answer the questions from that.</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>9%</td>
<td>I search the glossary for key words</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>5%</td>
<td>I use my class notes to come up with the answers</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>2%</td>
<td>I answer based on what I remember from this or previous classes</td>
</tr>
<tr>
<td>129</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2:** Question 2. When an assignment is given where you are asked to use the text to find information, which best describes how you use the science text?

### Table 3: Results of survey question 3

<table>
<thead>
<tr>
<th>response</th>
<th>number of responses</th>
<th>percent of total</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>2%</td>
<td>It is my primary study tool for tests.</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>39%</td>
<td>I use the text about equally as other sources (class notes, projects, study groups)</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td>37%</td>
<td>I use the text but I do not depend on it. Other tools are more important</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>15%</td>
<td>I rarely use the text when I study.</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>8%</td>
<td>I never use the text when I study.</td>
</tr>
<tr>
<td>103</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following question asked students to state their reasoning behind their answer to question 3. The results of this were grouped into similar answers. I developed a continuum of responses on a scale of one to six. Table 4 shows examples for each category.

| Table 4: examples of categories for question 4 responses |
|---------------------------------|-------------------------------------------------------------|
| category | Examples                                                                                                                                 |
| 1        | The text has all the information I need. I understand the text better than my notes.                                                |
| 2        | The text is useful for visualizing concepts. I make study guides from the text.                                                      |
| 3        | Using everything, notes, textbook, anything else is best.                                                                           |
| 4        | The notes have the same information, only condensed. The text is full of annoying analogies that are a waste of time.                  |
| 5        | The text explanations don’t mean anything to me, I don’t understand the text. I don’t like to read.                                 |
| 6        | I don’t study for tests.                                                                                                             |
Figure 4 shows the compilation of the students’ statements. By far, the most common comment was that the class notes were more convenient. Of the twenty three who said that they rarely or never use the text, six either felt that they didn’t understand the text or they don’t study for tests. Nearly all of the rest feel class notes are more convenient and “compacted”. Those that do use texts to study tended to bring out the value of a variety of sources and the texts use in clarifying, illustrating, and giving examples. Of unique note was the student who mentioned that the text is littered with ‘useless analogies that are just a waste of paper’. Certainly, much of the literature supports the use of such analogies.

Overall and not surprisingly, those who say they use the text see it as an important tool. Those who don’t use their text when studying do not place value on the text.

The fifth question asks students to describe their reading strategy when reading a science text. There was a wide range of responses, which I have bunched into six
categories. Table 5 gives examples of each category. Table 6 contains the compiled data for question 5 and 6.

**Table 5: examples of categories for question 5 and 6 responses**

<table>
<thead>
<tr>
<th>category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ask questions of the reading</td>
</tr>
<tr>
<td></td>
<td>Discuss the meaning behind the passage</td>
</tr>
<tr>
<td></td>
<td>Go back to previous topics that lead to this passage</td>
</tr>
<tr>
<td>2</td>
<td>Take notes</td>
</tr>
<tr>
<td>3</td>
<td>Identify the main ideas, highlight the key points</td>
</tr>
<tr>
<td>4</td>
<td>Answer pre-read questions, scan passage and ask questions first</td>
</tr>
<tr>
<td>5</td>
<td>Reread the passage or read aloud</td>
</tr>
<tr>
<td>6</td>
<td>Seek help from friend or teacher or notes, or review illustrations</td>
</tr>
<tr>
<td>7</td>
<td>No strategy, no response, or “just keep reading”</td>
</tr>
</tbody>
</table>

Figure 5 illustrates the difference between what the students say they are instructed to do and what they actually do. Interestingly, most students say that teachers want them to interact with their text (note taking, asking questions, or reword the passage), yet most students say that rereading, scanning the text, or simply asking a friend is what they do. I expected more organized strategies to be assigned by teachers. I think a difficulty may be in students interpretation of the procedures on paper.
The last question asked students to rate the readability of their science text compared to other texts. The data from this is illustrated in figure 6. One of the suggestions made in the literature is that science texts are inherently more difficult to read, due to the vocabulary and the way they are written. I wanted to see if this was the students’ perception. Very surprisingly, it was not. Most students feel that science texts are no different or somewhat easier than other texts.
**Quiz Results**

*Cell size quiz.*

For the first of the two pre-read quizzes, there were four questions (see the sample in the appendix). In scoring, each question was assigned two points. Some parts of the quiz were fairly objective, the answer is correct or not. Points are assigned accordingly for these parts. Question 1, and question 4 require a rubric.

Question 1 states: “What is the “information crisis” that a cell would reach if it grew without limit?” Full credit was given for answers like “DNA would receive too much demand, which increases as the cell grows”. Half credit was assigned if the answer addressed cell size issues but not the ‘information crisis’ aspect. For example: “The cell would have difficulty taking in and expelling enough materials.”

Question 4 states: Why does cell division solve the problems faced by larger cells? Full credit would go to “Cell division makes it easier and more efficient for cells to get molecules in or out of a cell, and the demand on the DNA is less because the same
volume of ‘cell’ now is divided in two with two sets of DNA.” Half credit would go to “Instead of a massive cell, it splits in two smaller ones so functions resume normally.” The student writing the latter answer demonstrated that they had a grasp of the concept, but may not have the entire picture. The table 7 illustrates the results for both the experimental and control groups.

**Table 7: Analysis of results on Reading quiz 1**

<table>
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<tr>
<th></th>
<th>No graphic organizer</th>
<th>Using graphic organizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Variance</td>
<td>4.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Observations</td>
<td>47</td>
<td>56</td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Df</td>
<td>101.0</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-1.7</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.047</td>
<td></td>
</tr>
</tbody>
</table>

As you can see, there is a significant difference in the quiz scores of the students who used graphic organizers as they read their text as compared to those who did not. A point to note is that the variance is high due to the wide range of responses.

**Independent Assortment Quiz.**

The second quiz was given after the introductory reading on independent assortment in the genetics unit. There were two questions, each assigned four points. Both of these were more open ended, requiring some discussion of how they were scored.

Question 1 states: “Explain what independent assortment means.” A full score should show a clear understanding of the concept. A score of 1 should show some comprehension, but with inaccuracies or omissions. Examples:

1. “Independent assortment means that genes segregate independently.”
“Are genes that segregate independently. They do it on their own without any help. They segregate during the formation of gametes.”

“Genes for different traits do not affect each other in formation of gametes which accounts for variations.”

“That genes for different traits can segregate independently. This means that each traits genes are totally separate, like flipping two coins. If one comes up heads doesn’t change the chances of the other coming up tails.”

The results of the data analysis for quiz 2 are in table 8. Again, there is a significant difference between the two groups. It should be noted that neither group showed a high average score considering eight points were possible. The variance reflects the fact that there were many in both groups with very low scores or no points at all.

<table>
<thead>
<tr>
<th>Table 8: Analysis of results on reading quiz 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>t-Test: Two-Sample Assuming Equal Variances</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Variance</td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
</tr>
<tr>
<td>Df</td>
</tr>
<tr>
<td>t Stat</td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
</tr>
</tbody>
</table>

*Interview Results*

There were six students selected to be interviewed as part of this study. They were selected based on their reading scores on the previous year’s STAR test. Students ‘d’ and ‘e’ were selected because of their higher scores. Students ‘a’ and ‘c’ were the middle level students, and students ‘b’ and ‘f’ were the lower performing students.
Their scores are listed here:

- Student ‘a’ 83% on reading proficient score in English literature.
- Student ‘b’ 78% in reading basic in literature.
- Student ‘c’ 72% in reading proficient in literature.
- Student ‘d’ 78% in reading advanced in literature
- Student ‘e’ 89% in reading advanced in literature
- Student ‘f’ 56% in reading proficient in literature

Table 9 illustrates each student’s description of what their normal reading strategy would be. The six students expressed a range of normal reading practice, from no real strategy to fairly advanced note taking. It is difficult to see any comparison between their responses and their reading scores. As with the survey, there are some whose response demonstrated a loosely organized system involving picking out the bold terms. On the other hand, the response of student ‘e’ seemed to illustrate a fairly advanced system involving note taking, formulating questions, and anticipating what the instructor will want them to know.
Table 10 shows what these students see as the advantages and disadvantages of using graphic organizers as they read. Generally there were favorable statements by all six about the use of organizers. Although they put it in different words, all seemed to focus on the way graphic organizers aid in clarifying relationships. Words like “better overview”, “more detail”, or “filtering information” seem connected to that aspect. The most interesting result here is the response of student ‘f’. After listening to her response to the next question, it was apparent that she had not done the assignment as instructed. Her statement was that she wrote the organizer from memory the day after doing the reading. Certainly, in that situation the organizer did not make it easier to find anything in the text.

Most of the interviewees found little or no disadvantage to using graphic organizers. I find I am drawn to the two responses that actually express disadvantages that might affect student perception or use of graphic organizers in the classroom. First, student ‘b’ s concern that sometimes it was hard to see concepts fit together. Certainly, this is the purpose of using graphic organizers. Although even student ‘b’ suggest that it is often helpful in making connections, there are going to be times where that is not enough. It is my opinion that the response of student ‘f’ Is the same that many students would give. It takes more time, and our students are very conservative with the time they will give to an assignment. Even student ‘d’ admits in the first question that she has pulled away from note taking when she reads due to the amount of time that it takes.
Table 11 contains the response from the third interview question. Here they were asked to assess how using a graphic organizer may have affected their ability on the quiz. Again, there are many glowing statements, which again make me point out the unusual statements. One in particular from student ‘b’ stands out. In her mind, being given questions after the read allows her to get to the main points faster, but she would miss some concepts. In one sentence, she made the assumption that all of the main points are covered in the questions at the end of the section and then admitted that that was not entirely true. A couple of others seem to reflect this feeling that using graphic organizers is not as easy, or maybe more time consuming. These same people recognize that it can be more effective. Considering her response to this question and her low performance on the quiz, student ‘f’ brings to the front some of the concerns I will address in the discussion section. It seems likely that she faked the organizer, and quite possibly did not do the reading.

<table>
<thead>
<tr>
<th>Table 10: Interview question 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>What advantages or disadvantages do you see in using graphic organizers and note taking strategies?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student</th>
<th>Response</th>
</tr>
</thead>
</table>
| A       | a) Graphic organizers help me understand the material better.  
          d) No disadvantage. |
| B       | a) Organizers help me see the main points and I can get more detail.  
          d) Sometimes I do not know how a concept fits into the organizer. |
| C       | a) I get a better overview of the material  
          d) none |
| D       | a) Graphics really help me. I usually organize with pictures and bullet points.  
          d) Notes can be messy with organizers |
| E       | a) It is better way of filtering information. Getting to the important stuff. Some of the analogies in the text are a waste of paper.  
          d) none |
| F       | a) It is easier to find information.  
          d) Disadvantage; they take much more time. |

Table 11 contains the response from the third interview question. Here they were asked to assess how using a graphic organizer may have affected their ability on the quiz. Again, there are many glowing statements, which again make me point out the unusual statements. One in particular from student ‘b’ stands out. In her mind, being given questions after the read allows her to get to the main points faster, but she would miss some concepts. In one sentence, she made the assumption that all of the main points are covered in the questions at the end of the section and then admitted that that was not entirely true. A couple of others seem to reflect this feeling that using graphic organizers is not as easy, or maybe more time consuming. These same people recognize that it can be more effective. Considering her response to this question and her low performance on the quiz, student ‘f’ brings to the front some of the concerns I will address in the discussion section. It seems likely that she faked the organizer, and quite possibly did not do the reading.
Reading Strategies

My observation of the students’ graphic organizers during the interview showed all range of skills, from extremely detailed to very incomplete. I could see that some may not be getting the most out of using this strategy.

Results of unit test questions

Cell division unit

On the cell division unit test, four questions were included having to do with regulation of the mitotic cycle, internal and external regulators, and cyclins. The questions are listed in the appendix. Each of the responses was scored based on the degree that the response completely answered the question. Three of the questions were assigned four points each and question two, which had three parts, was assigned six points. Results are listed in table 12.

<table>
<thead>
<tr>
<th>Student</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Taking notes on what I read helps me gain more information</td>
</tr>
<tr>
<td>B</td>
<td>I think using organizers or using answers from the book would have been the same. Questions usually get to the main points but the organizers get to concepts the questions don’t.</td>
</tr>
<tr>
<td>C</td>
<td>Without having taken notes on the reading, the quiz would have been more difficult. If I just answered questions in the book, I wouldn’t have had the same detail.</td>
</tr>
<tr>
<td>D</td>
<td>This approach benefits me a lot. I am a visual learner.</td>
</tr>
<tr>
<td>E</td>
<td>Being assigned questions would have been easier, but less effective. I did better on the quiz because of the note taking approach.</td>
</tr>
<tr>
<td>F</td>
<td>I think I would have been better off if I had made the organizer when I read the section. But I didn’t. I made the organizer this morning but I don’t think it helped me much.</td>
</tr>
</tbody>
</table>

Table 11: Interview question 3

- How did making a graphic organizer help you on the reading quiz today? Would it have been different if you were assigned to read and answer review questions?
The first observation of note is that the scores are low. The average score on these tests for all of my students was about 73% yet on these questions, the averages are much lower. Secondly, there is no significant difference between the two groups.

*Genetics unit.*

After I saw the results of the cell division test, I was concerned that my students may have been taken by surprise by a set of questions on material only learned from the reading. This is certainly not the usual in my classes. I would expect students to focus their attention on the concepts involved with the labs and activities they have done during the unit. Neither group of students did particularly well on that section of the test. I decided to have a minor change in my procedure for this second unit. When the reading assignment on human genetic disorders was given, I emphasized to the class that they would be tested on what they learn in that reading on the upcoming test. Each class was reminded of this again before the day of the test. I expected that this would increase scores in both the experimental and control groups.

There were two questions on each test, each asking the student to discuss the symptoms and genetic basis for a human genetic disorder presented in the reading. Each
response was scored based on their accuracy in describing the condition (two points) and the genetics (dominant, recessive, sex linked, trisomy). The results from these questions are summarized in table 13.

Table 13: genetics test results: genetic disorders questions
   t-Test: Two-Sample Assuming Equal Variances

<table>
<thead>
<tr>
<th></th>
<th>No graphic organizers</th>
<th>Using graphic organizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Variance</td>
<td>3.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Observations</td>
<td>48</td>
<td>57</td>
</tr>
<tr>
<td>Pooled Variance</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Df</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-6.52</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

Surprisingly, the average scores were still quite low for the control students. The group using graphic organizers performed much better on average. The variance of 7.0 on questions worth a maximum of eight points demonstrates that there were quite a few of scores in the extremes, either earning most of the points or very few. There is definitely a significant difference between the two groups in this assessment (p<.01).

Discussion

Overview

The purpose of this project was to test if teaching specific reading strategies would increase student comprehension of what they read. Students in two classes were taught to use graphic organizers and note taking strategies while reading. Another two were not given these strategies. Data was gathered from student surveys, post-read quizzes, select questions from unit exams, and interviews.
Summary of the Findings

Survey.

According to the survey results, although half of the students find science textbooks valuable in their studies, 15% find it useful only occasionally or not at all and the rest find it to be useful about half the time. When given assignments where they are to read a passage and answer questions, most skip to parts that seem to be about that question and do not read the rest. Nearly one fifth claim they get their information from pictures, glossary, or their notes and do not even read the text. Although 40% of the students felt the text was a valuable study tool, many claimed that they prefer using their notes because they are shorter and more concise.

When asked what strategies they use when reading, there was a wide spectrum of responses, from very efficient reading skills to none at all. The majority cited rereading passages, getting the information from others or no strategy at all. When asked what their instructors asked them to use. The majority responses involved note taking, highlighting key points and identifying main ideas. When asked how science texts compare to other texts as far as reading difficulty, they seem to refute the literature in saying that the texts are easier to read or no difference.

Post-read quiz.

In both sets of quizzes, the scores were quite low. In both cases, this was new material introduced by the reading assignment, so I am not alarmed by the scores. However, the high variance in both the experimental and control groups do suggest that scores were quite spread out. In fact, there were many scores close to zero. I would assume that many of those didn’t do the assignment or did not understand it. This would
account for the high variance and the fact that the variance was higher in the experimental group. There was a significant difference between the group using graphic organizers and the group that didn’t use them on both quizzes, but this should be weighed against the high variance.

**Student Interviews.**

When interviewing the six volunteers, all but one said that they take notes on what they read. Unless this group is not fair representation of the class, this seems to contradict the student survey results, where a smaller proportion of students suggested this strategy. All of the students said that graphic organizers were a benefit to them. The only disadvantages mentioned were that sometimes it is difficult to make connections between concepts, graphic organizers are messy, and they take too much time.

**Unit Tests.**

The scores on select questions on the unit tests were quite low. Again, the variances were high, mostly reflecting the higher than normal number of zero scores. These questions dealt with material only taught through reading assignments. No other reinforcement was given. On the first test there was no significant difference, but the second test showed a high degree of significance. Similar to the quizzes, there is a difference between the experimental and control groups but with the variance so high, I question the reliability.

**Conclusions**

Although there are some students who have well defined reading strategies, most of my students were only using the simplest of skills, if anything before this study. I expected to see patterns in what students said they were using in other classes, but there
wasn’t a clear one. This makes me think that the instruction of reading practices is not well reinforced in the classes of teachers who claim to use them. There may also be a failure of the students to incorporate strategies they use in one circumstance to others.

The low scores and high variances on the test and quizzes do not alarm me. When teaching a topic, I like to find as many ways to reinforce the concepts as possible. It is an unnatural situation for my students to be expected to learn a concept completely from the reading alone. On the other hand, the quizzes may be separating those that did the assignment from those who acquired it. Certainly there were some in the classes using graphic organizers who demonstrated a fairly good understanding of concepts that I am fairly sure they have not been taught anywhere else. There was a difference in comprehension between the group using graphic organizers and the group that wasn’t. This is enough for me to see that using this strategy can be effective.

Observations of student work showed that, although the classes showed higher comprehension, many students were not using these skills effectively. Along with this, some students who were diligently constructing graphic organizers in the beginning of the study were much less conscientious at the end of the study. For this to remain an effective tool there must be continuous reinforcement. There needs to be repeated modeling of effective skills accompanied by evaluation of student work.

The students themselves feel it is effective. The six interviewees were glowing with praise on how much they were helped by graphic organizers. I am concerned as to their sincerity, however. I wonder how much of that was their honest opinion and how much of that was students trying very hard to tell me what I wanted to hear. Considering that using graphic organizers well requires rereading, reflection, and writing, an
important question to ask is will students continue to use them. I tried a little experiment with my fifth period class at the end of the study. They were given a reading assignment and were given the choice to either doing a graphic organizer or reading and answering review questions. After the assignment, we talked about which they chose and why. I was surprised to see about an even mix in the class. I do not know what I was expecting, but still I was surprised. When asked why they chose what they did, all who spoke up stated that they learn far more using the graphic organizer. Those who chose to do questions instead added that if given a choice, they would probably not use graphic organizers, because they can get the assignment done so much faster without it. They openly admitted that they wouldn’t learn as much but they would search for key words from the questions and copy what they found without really reading in order to save time. This issue of time came up with two of the interviewees also. There were some students in both classes that made a point to tell me that they prefer to use graphic organizers and would use them whether they were required or not.

Recommendations

I believe there is enough evidence here for me to feel confident that teaching my students to use graphic organizers will improve their comprehension of what they read. Effective reading requires an effective strategy. Even the more academic students need to have that modeled. I will continue to use these strategies in my classes. By beginning at the start of the school year, it will be possible to model a more complete set of strategies such as those suggested by Fisher, Frey & Williams (2002). The difficulty I see is that these kinds of skills are only effective if they are used. I fear that students will revert to convenient short cuts when the novelty wears off.
Another concern I have is that I do not believe it is useful to rigidly require students to follow a particular set of skills if they are already using effective strategies. Some students will resist changing, justifiably so. I feel is important to be flexible if students can demonstrate that their strategies are indeed effective.

The survey results have brought me to the conclusion that the most powerful way to get students to incorporate reading strategies into all aspects of informative reading would be if they are using similar skills in each class. If our students began using a set of reading skills in their freshman science class and were required to use the same skills, with some modification in each science class, this may become part of their normal practice. I could see greater potential for benefit in Physics and Chemistry classes, where the concepts in the text may be more difficult to conceptualize.

On a global level, this study is more of a confirmation of the prevailing literature than documentation of something new.

Limitations of the Study

The most obvious limitation of this study was time. In two months, it is difficult to incorporate something new into the students’ bag of tricks and have them doing it well. I do not believe that all of my students had become experts at this reading strategy in the time of this study. This really should be ongoing. A more long term study may be useful to see if students take ownership of these reading strategies.

A second limitation has to do with the difficulty of testing the effect of one teaching strategy on the learning process. I do not use just one teaching strategy. Testing the effect of one piece of the puzzle is difficult. In this study, the quizzes and test questions were a bit unnatural assessments. Students can learn by just reading a book ,
but other activities and interactions will bring about a deeper understanding. I think it would be difficult to overcome these limitations without completely changing the assessments. Maybe more emphasis on interviews, where students show their graphic organizers and interpret them would be more effective.

I strongly feel the results of this study are most applicable to my classroom. This study was conducted on a small number of relatively motivated college preparatory students. The particular strategy chosen was selected with the abilities of those students in mind. I would expect that in classes with lower literacy levels, one may begin with a different strategy, and spend a greater amount of time on reciprocal reading exercises and modeling.

In the future, I would like to refine this reading program to incorporate other skills, including accessing prior knowledge and correcting misconceptions. I would like to continue experimenting on what is effective in my classroom. Beyond that, if a department wide program could be started, I would like to study a group of students for several years to see how their use of these skills changes.
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Appendices

SCIENCE TEXTBOOK USE SURVEY

Name ________________________________

Please respond to these questions honestly and openly. If a written response is required, please give thoughtful responses. The results of this survey will be used to assess curriculum modifications in this class. There is no grade consequence attached to any answer.

1. In general rate the impact science textbooks have had on your learning and understanding science.
   a. Is always a great help.
   b. Is often valuable.
   c. Is helpful about 50% of the time.
   d. I occasionally useful, but often of no help.
   e. I never find science texts that useful.
   f. I never use the science texts.

2. When an assignment is given where you are asked to use the text to find information, which best describes how you use the science text?
   a. I read the passage completely, then attempt to answer the questions.
   b. I review the questions first, then read the passage completely, then attempt to answer the questions.
   c. I search for the part of the question that deals with the question and read only that.
   d. I look at the pictures and diagrams and answer the questions from that.
   e. I search the glossary for key words.
   f. I use my class notes to come up with my answers.
   g. I answer based on what I remember from this or previous classes.

3. When studying for tests or quizzes, how much do you use the science textbook as a study tool?
   a. It is my primary study tool for tests and quizzes.
   b. I use the text about equally as other sources (class notes, study groups, etc).
   c. I use the text, but I do not depend upon it. Other tools are more important.
   d. I rarely use the textbook when I study for tests.
   e. I never use the textbook to study in science class.

4. Based on your last answer, state your reasoning for using/not using the text this way.
5. If you are reading a passage in a science text which is covering a new topic that is hard to understand, what reading strategies or techniques do you use to increase your understanding?

6. What reading strategies have you been asked to use in reading textbooks for other classes (history, English, etc)?

7. Compared to other textbooks, how would you rate science books as far as their readability and ease of comprehension?
   a. Science texts are far easier to read and understand.
   b. Science texts are somewhat easier to read and understand.
   c. Textbooks are all about the same to me.
   d. Science texts are somewhat harder to read and understand.
   e. Science texts are much harder to read and understand.

8. After you have used your biology text for 2 months, what do you like about it?

9. What would you with was different about your biology text?
Homework quiz #1
Date_________________ Period________

1. What is the “information crisis” that a cell would reach if it grew without limit?

2. The rate of exchange of materials in and out of the cell depends on the __________ of the cell. The rate at which food and oxygen are used up depends on the cell’s ______________.

3. What is the surface area of a 1cm x 1cm x 1cm cube?
   What is that cubes volume?

   What is the surface area and volume of a 2cm x 2cm x 2cm cell?
   From this, as a cell get larger, what happens to the surface area to volume ratio?

4. Why does cell division solve the problems of a larger cell?

   Homework quiz #2
   Date_________________ Period________

1. Explain what independent assortment means.

2. Describe an example to illustrate independent assortment in pea plants.
Test 1

1. What are cyclins and what do they do?

2. a. How do cells respond to contact with other cells?
   b. Under what circumstances would this type of cell cycle regulation be beneficial?
   c. Is this an external or internal regulator? Explain.

3. Human growth hormone (HGH) is sometimes prescribed to children who are not growing to increase their growth rate. What role must HGH be playing in the tissues of their bodies?

4. What is cancer? What is happening inside cells to make them cancerous?

Test #2

Date___________________  Period___________

1. Describe the symptoms and the genetics involved with each of these conditions: (8pts)
   a. Phenylketonuria (PKU)
   b. Sickle cell anemia