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Using Appropriate Strategies to Improve Students' Comprehension of Chemistry Texts: A Guide for Chemistry Teachers (Pp. 214-230)

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Abstract

Traditionally, the textbook has been the most frequently used instructional and learning aid in the hands of the teacher and the learner, through which officially prescribed curriculum is transacted. On many occasions, chemistry textbooks are challenging because they contain too many unknown technical terms, new ideas, and densely packed information. In addition, their complex organization and even unfriendly physical layout constitute serious reading comprehension difficulties. Undoubtedly, effective learning of chemistry requires good possession of reading comprehension skills. When students have reading comprehension difficulties, they have little or no ability of understanding written texts. This inability to read and understand what is read, means learning of chemistry may be stunted and sometimes hopelessly crippled at the grassroot. Unfortunately, contemporary research insight into science reading is lacking and science educators tend to focus on methods of teaching specific subject matter and students' misconceptions. As a result, learners lack the skills and strategies involved in reading and hence having reading comprehension difficulties. To help solve some of this problems, comprehension strategy instruction that can be adopted to assist less skilled readers acquire skills necessary for successful comprehension of chemistry texts are offered.

Keywords: *learning from text, text comprehension, reading comprehension difficulties, meta-cognitive reading strategies, graphic organizers.*

Introduction

Reading comprehension includes all of the processes related to constructing meaning from written language (including textbooks, student's guide, and other forms of written language). Constructing meaning indicates that often readers go beyond the meaning explicitly contained in the text and add to that meaning based on their experience and their ability to infer additional or deeper meaning. Thus reading comprehension is much more than the ability to read individual words and know what those words mean. To comprehend what one reads is to understand the meaningful message sent by the author.

In the context of this paper reading comprehension is defined as acquiring meaning from written text – with text being defined as a range of materials from traditional books to the computer screen. In this meaning – making process, the reader interacts with the print and is involved in making sense of the message. Readers comprehend text by acquiring meaning, confirming meaning, and creating meaning. In sum, reading comprehension is the process of meaning making.

The development of strategic reading comprehension of chemistry texts is crucial for science students because learning of scientific concepts and principles are strongly influenced by the possession of good reading comprehension skills. However, secondary school science teachers seem uninterested in combining reading instruction with content instruction. In addition, senior secondary school science (Physics, Chemistry, and Biology) curriculum extensively deals with the development of problem-solving abilities while neglecting the development of reading comprehension abilities.

With these prevailing conditions, chemistry students seem to lack necessary reading comprehension skills for successful comprehension of chemistry texts. These lacking skills are: determining importance while reading, self-monitoring comprehension, making predictions and inferences about text, and questioning while reading (Musthafa, 1996). Chemistry students who may be skilled readers of narrative texts often encounter difficulty in reading scientific and mathematics texts. This is because narrative texts deal with a broad theme and conveys information in story form which is easier for readers to understand while scientific texts are densely loaded with important information and minutely detailed logical arguments which render them

difficult to understand. In such texts, if one part of an argument is skipped or misunderstood, the remaining parts become incomprehensible.

The importance of teaching science students how to communicate effectively with scientific text has long been recognized by science educators (Mullin, 1989; Becker, 1995, Kalman and Kalman, 1996). Nevertheless, the senior secondary school chemistry curriculum traditionally emphasizes inquiry and mathematical aspects of the subjects matter. Such aspects do not generate tasks that require reading comprehension skills.

Unfortunately, contemporarily research insights into science reading is lacking and the science education community tends to focus on methods of teaching specific subject matter, the development of problem-solving skills, ways of improving practical work execution and paying little or no attention to text comprehension. As a result, less effective use of printed based resources in classroom is evident (Gottfried and Kyle, 1992; DiGisi, 1993).

For many chemistry students, good reading comprehension comes easily. For many others, it is a difficult and often confusing process. Teaching students to become skilled readers is also a difficult and challenging task because reading is such a complex process. Although teaching text comprehension strategy is a difficult task, it is necessary to develop reading-comprehension abilities and methods for their assessment if science teachers are to improve student performance. McNamara, Kitsch, Butler-Songer, and Kintsch (1996) showed how a high school reading course can influence student performance. It is equally clear that anything that teachers do to emphasize reading (inside or outside of school) will have a salutary influence on student achievement in science.

The purpose of this paper is to make chemistry teachers aware of the effective comprehension strategies that can be developed in their students through comprehension strategy instruction. This paper presented self-monitoring approach to reading, meta-cognitive reading strategy, visual structure, question-answer relationship and question-generation strategy as instructional strategies that are capable of helping chemistry teachers to enhance student comprehension of chemistry texts. The author believe that discussion on reading comprehension strategies as contained in this paper can inform other chemistry teachers who are willing to assist their students acquiring reading comprehension skills.

Theoretical Framework

A conceptualization of what reading is and how it takes place is foundational to any attempt to study what people do when they read and what can be done to improve reading comprehension which is the main focus of this paper. The act of reading involves a communication between author and reader during which skilled readers use their background of concepts and experiences to ask how they can make meaning or sense of what they are reading (Bacon, 1983). Skilled readers make connections between texts, from the text to the outside world, and from the text to their own experience while reading. They tend to make mental pictures of what they are reading and ask questions to themselves and to their instructors to enhance their understanding of the text (Keene and Zimmerman, 1997; Tovani, 2000).

Previous research has shown that actively processing difficult texts improves comprehension (Einstein, McDaniel, Owen and Cote, 1990; Chi, de Leeuw, Chiu and Levancher, 1994). This indicates that comprehension does not occur automatically. Readers must intentionally and purposefully work to extract and construct meaning from text by actively applying a variety of cognitive strategies. A convergence of evidence has identified a number of strategies that can be taught that reliably improve comprehension (National Reading Panel, 2000). Some of these include summarizing, finding the main idea, generating and answering questions, developing concept maps, self-monitoring. When readers use appropriate strategies, they are better able to retain, organize, and evaluate the information they read (Williams, 2005). Table 1 presents a list of key comprehension strategies.

Table 1: Key Comprehension Strategies

Strategy	Definition	Comments
Identifying important information	Reading a text and identifying the most important elements In narrative texts, these are the elements of a story map (setting, characters, problem, key events, and outcome). In expository text these are the main ideas.	This strategy is essential to knowing what the author is saying explicitly. Readers often use several strategies in combination to fully understand a text.
Inferring/Predicting	Judging, concluding, or reasoning from some given information. This can include anticipating what is going to happen or come next. This is the process of predicting.	This strategy helps students read between the lines and determine information that is not directly stated. It also helps students have a purpose for reading.
Monitoring/Cl	Knowing whether what you are reading is	This strategy enables

arifying	making sense and having a plan to clear up your understanding if it does not make sense.	students do things such as reread, look at diagrams and illustrations, think about how to figure out an unknown word, etc.
Generating and Answering Questions	Posing questions before reading or during reading, which requires students to integrate information and think as they read. In addition to answering questions of their own, students also profit from answering questions from the teacher and/or other students.	This strategy helps students set a purpose for their reading. When students ask questions from each other, the one asking the question must always know the answer.
Visualizing	Forming mental pictures in your head as you read.	This strategy is somewhat like inferential thinking where the reader forms visuals in his/her mind as reading takes place.
Summarizing	Pulling together the essential elements in a longer piece of text. This is like retelling in your own words.	For narrative text this strategy is focused on story elements, and for expository text it is focused on main ideas.
Synthesizing	Pulling together the key ideas from several sources of information.	This strategy requires the same basic process as summarizing except it is applied across several sources. This strategy is important as students study content area such as science or social studies.
Evaluating	Making judgments about what has been read	This includes making judgments about the text, the way characters responded to certain situations, and judging the validity and accuracy of the content. This is the process of critical reading.

Source: Coyne, M.D., Kame'enui, E.J., & Carnine D.W.(2007).Effective teaching strategies that accommodate diverse learner's (3rd ed.) Upper Saddle River, New Jersey: Pearson Education, Inc.

Although reading instruction alone can teach students many of the skills and strategies they require for reading content area materials successfully, students also must have ample opportunities to apply these skills and strategies in "real" reading situations-that is as they read in the content area (e.g. chemistry texts). Thus all teachers both in the secondary schools and

universities must play a vital role in teaching students to use reading comprehension skills and strategies to learn chemistry contents so as to become independent readers and learners.

Reading Instruction in Content Area

Each content area has its own language or vocabulary. Content area reading materials present students both with new and often difficult words, as well as with familiar words that may be used in new ways. If a student does not know the meanings of a sufficient proportion of the words in these reading materials, he or she may become frustrated and skip important words, which can make comprehension impossible.

To comprehend their content area reading materials, students must be able to determine the meanings of general, specialized, and technical vocabulary.

- (1) General vocabulary: This consists of words that each student knows and uses as part of everyday activities. However, even familiar words can pose problems if students are not aware that words can have different meanings, or connotations, that are determined by the context in which they appear.
- (2) Specialized general vocabulary: This consists of words that have specific meaning for content area subjects. It is context that determines the meaning of such words. For example, the word *solution* will have different meanings in chemistry and mathematics texts.
- (3) Technical vocabulary: This includes words that relate specifically to each content area or topic. For example, the word *electioneering* is most likely to appear in political science texts, *electromagnetism* in physics texts, and *electroplating* in chemistry texts. Students must learn the definitions of these words to understand content area reading materials and to learn the language of a discipline.

Because vocabulary knowledge and reading comprehension are so highly related, effective content area vocabulary instruction must provide students both with explicit instruction in specific content-related words and concepts and with strategies that help to learn words independently. To achieve this objective, the instructional practices to be adopted must be capable of helping students:

- a) to create mental, or visual images associated with a technical vocabulary word so as to facilitate recall of its meaning. This is often referred to as the keyword techniques;
- b) to link new vocabulary with background knowledge by having students brainstorm and describe what they already know about the topic being studied;
- c) to focus on the semantic relationships of new and familiar words and concepts through activities such as semantic mapping, semantic feature analysis, and categorization;
- d) to restate dictionary of new words in their own words and to make up sentences using the new words;
- e) to use synonyms, antonyms, and dictionary definitions to understand the meaning of specialized and technical vocabulary;
- f) to analyze the structure of new words (affixes, inflections, compound words, and contractions) to determine their meanings;
- g) to use contextual analysis activities that require students to use semantics and syntactic features of sentences to determine the meaning of new words. Such activities include a cloze procedure, rereading sentences without using the new word, and reading sentences that appear before and after the sentence with the new word;
- h) to use a combination of strategies, such as dictionary definitions and contextual analysis (each one used alone has not proven to be effective instruction);
- i) to maintain personal content-related word lists or word banks; and
- j) to work cooperatively to figure out meanings of new words through contextual analysis (National Research Council, (1998).

Instructional Strategies to Facilitate Reading Comprehension

Secondary school teachers as a whole remain unconcerned with the reading process and as such contribute largely to student's reading comprehension inadequacies (Abe, 1991). Speaking in the same vein, Yusuf (1995) states that numerous studies have revealed that Nigerian students have various reading comprehension difficulties. Among the reading problems exhibited by students at the secondary school level as identified by Unoh (1980) and

Obah (1989) are students inability to separate relevant from irrelevant details, inability to bring out facts from the passage, poor retention and recall of what is read, and a weak vocabulary base. This implies that they are less skilled readers. Part of the reason for this inefficiency is attributed to the students and a greater part to the method being adopted by teachers in teaching. Since chemistry texts and narrative texts have different structural, lexical, semantic features, conceptual foundation and goals there is need to approach reading tasks strategically. Dowhower (1999) has demonstrated that direct instruction in strategy use can improve the reading comprehension skills of students and students lacking in these skills who receive such instruction often become indistinguishable from more skilled readers. The following are comprehension instructional approaches that can be adopted by chemistry teachers when planning reading instruction. These appear to have a firm scientific basis for improving text comprehension

1. Comprehension Monitoring

The Self-Monitoring Approaches to Reading (SMART) which was developed by Underwood (1997) can be adopted in improving the reading comprehension skills of chemistry students. This is because SMART has been found to help matured readers in self-assessing their reading comprehension. This comprehension strategy instruction is based on two attributes of a good/skilled readers: firstly, they pay attention to how well they understand what they read. If there are gaps in comprehension, they do something about it, for example, by reading sections of the text; secondly, they ask questions of the text as they read. If there are parts of the text they do not fully understand, they take that as a problem to be solved than simply accepting their lack of comprehension. In this strategy, instructors ask students to stop at the end of each paragraph to ask themselves whether they understand the main points of what they read, whether it “clicks” or clinks: (Underwood, 1997, p.19). If it clicks” students put the meaning of that section into their own words and if it clunks”, students pinpoint what went wrong and formulate questions that might lead to resolving their confusion. Comprehension monitoring teaches students to:

- (a) be aware of what they do understand
- (b) identify what they do not understand
- (c) use appropriate strategies to resolve problems in comprehension

2. Metacognition

Metacognition can be conceived as individual's awareness of and ability to monitor, adjust, and regulate his/ her cognitive actions in regard to learning. It is a technique that tests reality by checking and monitoring learning activity (Adler, 2004). Metacognition is a hidden level of behaviour that involves focusing on conscious knowledge about knowledge and its relations to intellectual performance. According to Artzt (1994), metacognitive analyses of the thought processes that lead to incorrect/correct solutions are extremely beneficial. Metacognition in science reading comprehension is important because students have to be encouraged to think about how they comprehend a text and what they should do about the text. This, in turn, provides them with a more thorough understanding about how to comprehend a text. It helps students to reflect on what they have learned or on mistakes that they have made (Quinn and Wilson, 1997). Skilled readers of science texts use Metacognitive strategies to think about and have control over their reading at various points during reading. Before reading a text, skilled readers do some combination of the following:

- a) **Clarify the purpose of reading:** The purpose of reading might be: "I need to find out....; I need to understand....? or I need to answer the following questions.....?"
- b) **Preview or survey text:** In senior secondary school textbook reading, the student might first look at the chapter questions at the teacher's assignment or at the section headings. In these ways, the student is surveying the text and gaining a general orientation to the content of the text.
- c) **Predict the content or outcome:** predicting what occur in the text or what will be learned from the text helps the reader attend to the material in a focused manner.

While they are reading, skilled readers pause and do some combination of the following.

- a) **summarize:** they try to summarize to make sure they comprehend.
- b) **Image:** they create a mental image of what they have read.
- c) **Organize:** They organize the information –make connections through the use of graphic and semantic organizers.

- d) **Elaborate:** They connect what they are reading to what they already know this can be facilitated by routinely asking “why “questions or other questions while reading.
- e) **Reread:** They reread parts that they know they did not properly understand. This of course assumes that they are monitoring their comprehension. Students should be taught to routinely ask themselves, “Does this make sense?”

After completing a text, skilled readers do some combination of the following:

- a) **Summarize:** They try to summarize what they have read to make sure they comprehend it.
- b) **Review:** They review in their minds the main points of the text.
- c) **Answer questions:** They answer questions that may have been provided by the teacher.
- d) **Apply the content:** They try to apply the content to other domains they are familiar with or to their own experience.
- e) **Make judgments:** They make judgments about how good the reading was, how much they liked it, whether the reading met its purpose, and the like.

Comprehension strategy instruction aiming at encouraging science students to use metacognitive strategy should have the potentials of developing students’ ability in using several comprehension monitoring strategies:

- a) Identify where the difficulty occurs

“I don’t understand the last paragraph on page 3 of my chemistry text”

- b) Identify what the difficulty is

“I don’t get what the author means when he says, bonds become stronger as more electrons are shared between the atoms.

- c) Restate the difficult sentence or passage in their own words

“Oh, so the author means that sharing more electrons strengthens the bond”

- d) Look back through the text

“The text says, the polarity of the water molecules causes it to form hydrogen bonds with other water molecules, but I don’t understand hydrogen bond. May be if I reread the previous chapter, I can understand it”.

- e) Look forward in the text for information that might help them to resolve the difficulty.

The author wrote that natural and artificial solutions containing a mix of solutes which together resist changes in P^H and thereby acted as buffer solutions’ Hmm, I don’t understand how natural and artificial solution can do that..... Oh, the next subheading is called Buffer solutions, I’ll read this section to see if it tells how they resist changes in pH .

3. Visual Structures or Graphic Organizers

Visual structures includes spatial learning techniques such as maps, chains, webs, trees, matrices, frames or clusters, and diagrams that provide a visual representation of text content to facilitate comprehension. Visual organizers show key parts of a reading and the relationship among those parts, allowing for a holistic understanding that can help students understand important ideas and the organization of texts (Jones Pierce and Hunter, 1989; Dowhower, 1999). Graphic organizers are very useful in facilitating comprehension in the sense that they can:

- (a) help students focus on text structure “differences between endothermic reaction and exothermic reactions” as they read
- (b) provide students with tools they use to examine and show relationships in a text
- (c) help students write well-organized summaries of a text. In using the graphic organizers to enhance reading comprehension of science texts, the following steps are suggested
- (d) allow the students to survey the text by paying attention to the title, subheadings, and illustrations so as to determine the topic and objectives of the text.
- (e) enough time should be given to students in order to begin to form a theory of the structure of the text and which graphic organizer (map, chart, web, etc.) might best represent it

- (f) instruct the students to read the text with that graphic representation they have in mind and this will help them to approach their reading with specific purposes.

After reading the text, students should complete the graphic organizer, using the questions or categories provided by the instructor in the appropriate frame as a guide.

To facilitate comprehension further, students can then use the information in the graphic representation that they have created to write a summary of the text. Researches claim that “graphic organizers and outlines are fundamental to skilled thinking because they provide information and opportunities for analysis that reading alone and linear outline cannot provide” (Jones, Pierce and Hunter, 1989,p.25). Graphic representations can also foster non-linear thinking and promote “in depth processing and rich contextual associations” in that they can be read from left to right or top to bottom unlike linear outlines or written summaries (p.21).

4. Question-Answer Relationship (QAR) Strategy

In this strategy, the students read a passage silently and the instructor models appropriate questions that could be asked about the selection while integrating background and knowledge and textual information; following that the students are instructed to answer questions about the text. The Question-Answer Relationship Strategy (QAR) encourages students to learn how to answer questions better. Students are asked to indicate whether the information they used to answer questions about the text was textual explicit information (information that was directly stated in the text), textually implicit information (information that was implied in the text), or information entirely from the student’s background knowledge. In planning comprehension strategy instruction for the improvement of chemistry students comprehension skills, four different categories of questions formulated by Walker (2000) can be adopted. These categories are:

- (a) “Right There”. Questions found right in the text that ask students to find the one right answer located in one place as a word or a sentence in the passage

Example: What is the shape of an *S* orbital?

Answer: Spherical shape

- (b) "Thinking and Search". Questions based on the recall of facts that can be found directly in the text. Answers are typically found in more than one place, thus requiring students to "think" and "search" through the passage to find the answer.

Example: Explain why graphite can conduct electricity, unlike diamond.

Answer: Graphite contains delocalized electrons in its crystal structure.

- (c) "Author and You". Questions require students to use what they have learned from reading the text. Student's must understand the text and relate it to their prior knowledge before answering the question. Example: Using your knowledge of chemical bonding, explaining why the boiling point of n-propanol is higher than that of ethyl methyl ether.
- (d) "On Your own". Questions are answered based on a student's prior knowledge and experiences. Reading the text may not be helpful to them when answering this type of question.

Example: Why do some clothes lose colour easily?.

If properly used, questions can be effective because they:

- (a) Give students a purpose for reading
- (b) Focus student's attention on what they are to learn
- (c) Help student's to think actively as they read
- (d) Encourage student's to monitor their comprehension
- (e) Help students to review content and relate what they have learned to what they already know.

5. Question- Generation Strategy

Instruction that teaches how to formulate questions about a science text can help students to determine which information is important, leading to improvements in text comprehension (Dole, Duffy, Roehler and Pearson, 1991; Walker, 2000). In this strategy, students generate their own questions in order to become more active in their reading. Students can be introduced to self-questioning by developing pre-reading questions with the instructor and then by formulating questions about main ideas while reading (Long and Long, 1987). Studies in reading comprehension have shown that students

who were taught to generate questions from the main ideas of paragraphs outperformed students who were not taught to use self-questioning strategies (Long and Long, 1987). When students ask themselves questions before and or during reading, they read text in search of answers and are engaged in active comprehension (Underwood, 1997). When they revisit questions that were generated at the start of a reading task, they can reflect on the sense they made of the text and can self-asses their own comprehension (Underwood, 1997).

Conclusion

Reading is considered as a powerful instrument for the acquisition of scientific principles and concepts although students and teachers seen not to have recognized this through the way it is taught and learnt. The high rate of failures in national examinations (e.g. West African Senior School Certificate Examination) affirms the assumption that some Nigerian students encountered reading difficulties and that ineffective methods of teaching reading are often employed in classrooms. English language educators (Lawal, 1994; Freeman, 2003; Seyler, 2004) observed that teachers of reading comprehension adopt a dogmatic approach to teaching by following rigidly the text without supplementing, modifying or improvising materials and techniques that will suit and later cater for students need. Similarly, the author notices that chemistry teachers who performed well in content instruction are often at a loss when it comes to reading instruction because their pedagogical training exclude this important aspect of learning. To cater for this deficiency, this paper offers intervention instructional strategies from which teachers can select those ones that best fit their students needs. The list of strategies provided here should be viewed as a repertoire of diverse comprehension strategies that can be used in varying ways depending on student needs, teacher goals, and the demands of the reading task. In implementing any of the selected comprehension strategy for the purpose of improving text comprehension the following steps are recommended:

- (1) Direct explanation – The teacher explains to students why the strategy helps comprehension and when to apply the strategy.
- (2) Modeling – The teacher models, or demonstrates, how to apply the strategy, usually by “thinking aloud” while reading the text that the students are using.
- (3) Guided practice – The teacher guides and assists as they learn how when to apply the strategy.

- (4) Application- The teacher helps the students practice the strategy until they can apply it independently.

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