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# Effect of Previous Knowledge on Students' Cognition in Some Content Areas in Chemistry

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**Abstract**

This study was undertaken to determine the effect of previous knowledge on students' cognition on some content areas in chemistry. Reading, Comprehension monitoring, Summarizing, Questioning, Instruction, and Evaluation (RCSQIE) forms the component of the previous knowledge. The sample consists of 80 senior secondary 11 students from two schools in Jos, Plateau state, Nigeria. The design of the study was the pre – test post – test experimental research design. The instruments used were Fry readability model used to determine the readability level of the selected textbook and Science Reasoning Task used to determine students cognitive level. The experimental group was given a previous knowledge of the topic before lessons by allowing them to read the topic before classes while the control group had no previous knowledge. The cognitive levels of the students were determined before and after treatment. The findings showed that the experimental group students' cognitive level improved with previous knowledge. It was concluded that previous knowledge improves students understanding of chemistry. It was therefore recommended that teachers' should encourage students' to read content before lessons.

**Keywords:** Chemistry, cognition, content areas, previous Knowledge.

## Introduction

Cognition is the scientific term for "the process of thought" (Demide, 2000; Oloyede, 1996; Ashmen & Conway, 1993). It usually refers to an information processing view of an individual's psychological functions, development of concepts; individual minds, groups, and organizations. Cognition can be natural or artificial, conscious or unconscious. Within psychology or philosophy, the concept of cognition is closely related to abstract concepts such as mind, reasoning, perception, intelligence, learning, and many others that describe capabilities of the mind and expected properties of an artificial or synthetic "mind".

Content area texts are conceptually dense and organized for information thus demanding special reading skills for inference and critical thinking (Allington, 2002) to discern the worthwhile information (Bean,2001). Students' lack of reading and comprehension ability in secondary schools translates into failures later in life. Students are unprepared for the academic language encountered in secondary schools (Wright, 1998), while little advancement is being made in developing the reading skills of secondary school students (Snow, 2002)

Understanding the language of the content areas (topics being taught) is essential to students' comprehension. If students fail to grasp the language, then they fail to grasp the concepts in the language (Meltzer, 2001). Students must be able to learn from the language of

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the expository texts even when the topic is unfamiliar and the reading is demanding (Alexander & Kulikowich, 1991; Barton, Heidema & Jordan, 2002).

Comprehension includes translation, interpretation, and extrapolation of ideas. Strategies which include question generation, comprehension monitoring, summarizing, question answering, graphic organizers (diagrams, concept maps), have proved useful in facilitating comprehension.

Some popular study strategies, such as predictionand Preview, Question, Read, Reflect, Recite, Review (PQ4R), have been researched. These kinds of programmes are called Cognitive Strategy Instruction (CSI) of the instructional strategy to facilitate comprehension. This is because it was used by the students during their private study in the absence of the teacher. Text books have several purposes such as providing a framework for guidance, enforcing learning, clarity, amplification and sometimes interpretation of views, not clearly experienced by the instructors (Smith, 1999).

Oloyede (1996) have argued that students ability to comprehend ideas and concepts is determined by his or her level of cognitive development and that the mismatch between the level of the pupils thinking and the intellectual demands of the subject matter is a major cause of learning difficulties in science. One approach to tackling the lack of comprehension of chemistry concepts is to limit the scope and depth of the curriculum for students who can think mostly in the concrete operational mode.

This research is experimenting on the effect of previous knowledge using Reading, Comprehension monitoring, Summarizing, Questioning, Instruction, and Evaluation strategies. (RCSQIE) RCSQIE is based on the two concepts- the schema theory and the instructional frame work. From the schema theory, the idea of activating prior knowledge in the subject matter to improve comprehension was adopted. From the instructional framework, the indirect instructional strategy was adopted which entails high level student involvement by taking advantage of the students interest and curiosity, and encouraging them to build up their learning experiences and further enhance comprehension. The teacher arranges the learning environment by giving the student the topics and the objectives, and recommending the books to facilitate the building up of prior knowledge before actual teaching takes place. The teacher provides opportunity for student's involvement, and when appropriate, provides feedback to students while they conduct the inquiry. Indirect instruction relies heavily on the use of print, and human resources which is also reflected in RCSQIE as the textbook acts as the print media and the teacher the human resource. Learning experiences are greatly enhanced through cooperation between teachers and the students. Just as the indirect instruction strategy, the RCSQIE allows the students to investigate or discover something in order to benefit from later instruction; focuses on personalized understanding and long term retention of concepts or generalizations, of which in the overall, process is as important as product.

RCSQIE forms the component of the previous knowledge as the instructional method, and teaching strategy to see if it will make concept learning a lot easier and more readily attainable for students who are not yet operating in the formal operational level. It involves the teacher and the student working together in order to improve student's cognition, and comprehension in some concepts in chemistry.

The main purpose of the study was to determine the effect of previous Knowledge on student's cognition and comprehension on some selected content areas in chemistry. Reading, comprehension monitoring, summarizing, question generation, instruction, and evaluation (RCSQIE) makes up the previous experience.

The following research questions were investigated in this study:

(i) What is the Fry's readability level for the text book used in RCSQIE to facilitate comprehension?

(ii) How many of the students' fall between the late concrete operational and the formal operational reasoning levels before treatment?

(iii) How many of the students fall between the late concrete operational and the formal operational reasoning levels after treatment?

## Theoretical Framework

*Schema Theory*

Schemata, or prior knowledge, are a quantum of knowledge that exists in our minds and represents all that a person knows about a given concept (McKenna & Robinson, 2002; Ryder & Graves, 1994). They are the central guidance system in comprehension representing universal concepts and generalizations (Readence, Bean & Baldwin, 2001: See details in Demide, 2011).

*Instructional Framework*

Instructional framework is another important aspect of checking communication with students. Instructional Framework, identifies and illustrates the interrelationship among instructional approaches, that when properly used, are acknowledged to be consistent with sound educational practice (Saskatchewan, 1988). The approaches are referenced to the goals of education and apply to the objectives of the various curricula.

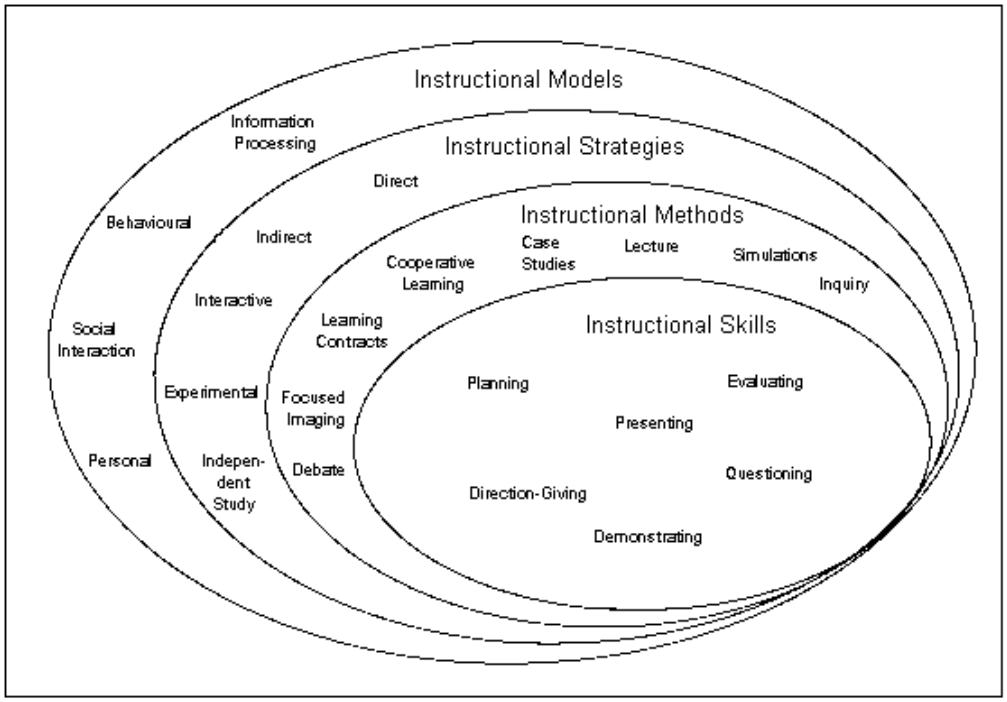


**Fig 1.** Defining the Instructional Framework (Saskatchewan, 1988).

Decision making regarding instructional strategies requires teachers to focus on curriculum, the prior experiences and knowledge of students, learner interests, student learning styles, and the developmental levels of the learner. Although instructional strategies can be categorized, the distinctions are not always clear-cut. For example, a teacher may

provide information through the lecture method while using an interpretive method to ask students to determine the significance of information that was taught. After deciding on appropriate instructional strategies, a teacher must make decisions regarding instructional methods.

What children learn depends not only on what they are taught but also on how they are taught, their developmental level, and their interests and experiences (Saskatchewan, 1988). Details in Demide (2011).

*The Use of Fry's Readability Graph:*

Teachers often would like to check the readability of a piece of writing. How well the author succeeds will depend on the readability of the text. When writing a text-book, a work-sheet or an examination paper, an author is intent on transmitting information to the reader. Readability is concerned with the problem of matching between reader and text. An accomplished reader is likely to be bored by simple repetitive texts. A poor reader will soon become discouraged by texts which s/he finds too difficult to read fluently.

This is likely to happen when the text is:

- poorly printed,
- contains complex sentence structures, long words or
- Too much material containing entirely new ideas.

The term readabilityrefers to all the factors that affect success in reading and understanding text.

These factors include:

1. The interest and motivation of the reader.
2. The legibility of the print (and of any illustrations).
3. The complexity of words and sentences in relation to the reading ability of the reader.

Objective measures of readability are now widely used. They are formulae or graphs which are based on enormous amount of research evidence. A readability formula predicts the reading level of the text. This is expressed as the chronological age and is accurate to about +/_ one year. The Fry's readability graph ( developed by Edward Fry, Ph.D., director of the Reading Center at Rutgers University, designed the following "Graph for Estimating Readability" of documents) works by selecting examples of 100 words, finding y, the average number of sentences per 100-words (calculating to the nearest tenth); then finding x, the average number of syllables per 100-word sample. The Fry graph is then used to determine the reading age, in years. This test is suitable for all ages from infant to upper secondary. The curve represents normal texts, points below the curve imply longer than average sentence lengths. Points above the curve represent text with more difficult vocabulary (as in school science texts). Why calculate Readability? A person would calculate readability if they are interested in knowing the reading level of a particular book or reading selection. Determining Readability using Fry's Readability will provide you with the grade level or age level of the selected material.

- To apply this Fry's readability graph practically, these are the steps to take.

1. Randomly select three 100-word segments of your writing.
2. Count the number of syllables in each 100-word block and calculate the average.
3. Count the number of sentences in each 100-word block and calculate the average.
4. Plot the point on the graph where the numbers from steps 2 and 3 intersect.

If the plotted point falls in one of the black areas on the graph, the grade level scores are not valid. If your points fall in different parts of the graph, select three more 100-word segments. Your material has a wide range of readability.

• The special rules that should be remembered when applying Fry's Readability Graph are that:
• "Sentences" end with a [.], [?], [!], andnot a [:], [;], or [,].
• Hyphenated words count as one word.
• Count proper nouns.
• Numbers are not counted.
• Count abbreviations as their original whole word.
• Count lists as one sentence each if items are separated by commas or semicolons. Lists with full sentences (like this one) count for as many sentences as are in the list.

*For example:*

*Babies born to women who are covered by one of Iowa's health care programs are covered through the month of their first birthday, provided the baby continues to live with the mother and reside in the state of Iowa.*

• Off the chart according to Fry's Readability Graph. (The chart only goes to "college" level, at grade 14.)

*Are you pregnant? Do you get health c noverage from an Iowa program? If you do, your baby will also be covered. Coverage will last until the end of the month of your baby's first birthday. The baby must live with you in Iowa.*

• Grade 3, according to Fry's Readability Graph
This can help you decide if a book is too easy or too hard for the intended reader (http://School discovery education.com).

*Review of Empirical Studies*

Reciprocal teaching is an instructional procedure designed to teach students cognitive strategies that might lead to improved comprehension. The learning of cognitive strategies such as summarization, question generation, clarification, and prediction is supported through dialogue between teacher and students as they attempt to gain meaning from text (Rosenshine & Meister, 1994.) One of the most powerful tools of applied cognitive science is the training study. Guided by emergent theoretical analyses of the processes involved in a particular academic domain, researchers have designed cognitive skills training studies that have resulted in significant improvement in such areas as physics and mathematics problem solving, and comprehension.

Much strategy instruction research has considered a single strategy. For example, Armbruster, Anderson & Ostertag (1987) compared 5th-grade students who were specifically taught how to summarize social studies text (treatment students) to students who received conventional question discussion instruction (control students). Treatment students scored significantly better than control students on a short essay post-test and on written recalls, and the treatment was more beneficial for high-comprehending students than for low-comprehending ones. Many researchers have tried teaching several strategies. One well-known multiple-strategy program is Reciprocal Teaching (Palincsar & Brown, 1984). Middle-school students worked in small groups, first with teacher support and later without a teacher. They learned to ask and answer questions, summarize, make predictions about the text, and clarify anything they did not understand. In the beginning, the teacher modeled how to use each strategy and coached (scaffold) students as they learned to use it. Eventually, students

were able to use the strategies on their own (Rosenshine & Meister, 1994). Alfassi (1998) found similar results 9th-grade students. In line with these researches, this work is using similar strategies to see if the SSSII chemistry students' achievement and cognition could be improved. Strategy instruction can have a big impact on student learning, but it also takes a long time to teach it and ensure that students have enough practice.

## Methodology

The study subjects consist of 80 SS11 students from two secondary schools in Jos, Plateau state, Nigeria. Forty students offering chemistry were used as study subjects from each school. One school was used as control and the other as experimental. The study utilized the pre-test – post-test non-equivalent control group design (Oloyede, 2007).

Two instruments were used for data collectionas follows:

I. The Fry's Readability graph. An adopted instrument from Fry (1977).
II. Science Reasoning Task (SRT) II on Volume and Heaviness constructed by Shayer and Wylam (1978). It has an internal consistency of 0.78, with a test – retest reliability of 0.89 for this study. Both instruments were sensitized and found to be culture fair.

For the experimental group, the first twelve practical questions in the SRT II test were demonstrated to the students for about 15 minutes, before the test was administered to the students and students were instructed to record their individual observations. They were arranged in groups of five and allowed to answer the questions that followed in sixty minutes. RCSQIE was administered for three weeks. This included private reading sessions which were done by the students on their own before coming to the classroom for lessons, comprehension monitoring which involved personal questions that the students were expected to ask themselves individually were encouraged; summaries of notes were made by the students, and were encouraged to note difficult words. Instruction was then given to the students by the teacher using the Frayer model (2011) and concept mapping, along with the lecture methods. In the fourth week; the SRT II was re-administered. Data collected were then analysed.

For the control group, the first twelve practical questions in the SRT II test were demonstrated to the students for about 15 minutes, before the test was administered to the students and instructed to make their record individual observations. They were arranged in groups of five and allowed to answer the questions that followed in 60 minutes. RCSQIE was not administered to the students. They were taught using the lecture method only. In the fourth week; the SRT II was re-administered as post- tests. Data collected were thenanalysed

## Results and Discussion

The findings of the study are presented in Tables 1 and 2.

**Table 1.** Fry Readability Level

| | Page(s) | Number of Syllables | Number of Sentences |
|---|---|---|---|
| Beginning Selection | 29 | 173 | 4 |
| Middle Selection | 154 | 163 | 5 |
| Ending Selection | 394 | 148 | 4 |
| Sum | | 484 | 13 |
| Average (Sum divided by 3) | | 161.3 | 4.3 |

Grade Level Determined by Fry : 12
Age : 17
Inference: Suitable as a normal Text.

**Table 2.** Students' performance at various cognitive levels of the experimental and the control groups before and after treatment.

| s/no | Exp pre | Those in 2B and above | Exp post | Those in 2B and above | Cont pre | Those in 2B and above | Contpost | Those in 2B and above |
|---|---|---|---|---|---|---|---|---|
| 1 | 2b/3a | √ | 2b | √ | 2a | - | 2b | √ |
| 2 | - | - | - | - | 2a | - | - | - |
| 3 | 2a | - | 2a | - | 2a/2b | - | - | - |
| 4 | 2a | - | 2a | - | - | - | 2a | - |
| 5 | 2a | - | 2a | - | 2b | √ | - | - |
| 6 | - | - | 2a | - | 2b | √ | 2b | √ |
| 7 | 2a/2b | - | 2a | - | 2a | - | 2b | √ |
| 8 | - | - | 2a/2b | - | 2b | √ | 2b | √ |
| 9 | 2a | - | - | - | 2a | - | - | - |
| 10 | - | - | 2a | - | - | - | - | - |
| 11 | - | - | 2a | - | 3a | √ | 3a | √ |
| 12 | - | - | - | - | - | - | 2a | - |
| 13 | 2a/2b | - | - | - | - | - | - | - |
| 14 | 3a | √ | 3a | √ | 2b | √ | - | - |
| 15 | 2b/3a | √ | 2b/3a | √ | 2a | - | 2a | - |
| 16 | 2b | √ | 2b | √ | - | - | 2b/3a | √ |
| 17 | 2b | √ | 2b | √ | - | - | - | - |
| 18 | 2a | - | - | √ | - | - | 2b/3a | √ |
| 19 | 2b | √ | 2b | √ | 2b | √ | - | - |
| 20 | 2b | √ | 3a | √ | 2b | √ | 2a | - |
| 21 | - | - | 2b | √ | 2b | √ | 2b | √ |
| 22 | 2b/3a | √ | 2b | √ | - | - | - | - |
| 23 | 2b/3a | √ | 2b | √ | 2b | √ | 2a/2b | - |
| 24 | 2a | - | 2a | - | - | - | - | - |
| 25 | 2a | - | 2b | √ | - | - | - | - |
| 26 | 2b | √ | 2b | √ | 2b | √ | 2b | √ |
| 27 | 2b | √ | 2b/3a | √ | 2b | √ | 2a | - |
| 28 | - | - | - | - | - | - | - | - |
| 29 | - | - | 2b | √ | - | - | 2a | - |
| 30 | 2b | √ | 2b | √ | - | - | 2a | - |
| 31 | 2a | √ | 2b | √ | 2b/3a | √ | 2b | √ |
| 32 | - | - | 2a | - | - | - | 2a | - |
| 33 | - | - | - | - | 2a | - | 2b | √ |
| 34 | 2b | √ | 2b | √ | 2a | - | 2b | √ |
| 35 | 2b | √ | 2a | - | - | - | - | - |
| 36 | 2a | - | 2a | - | 2a | - | - | - |
| 37 | 2b | √ | 3a | √ | 3a | √ | 3a | √ |
| 38 | - | - | 2a | - | - | - | - | - |
| 39 | 2b/3a | √ | 3a | √ | - | - | - | - |
| 40 | 3a | √ | 3a | √ | 3a | √ | 2b | √ |
| Total | | 18 | | 21 | | 14 | | 14 |

Key: 1 Preoperational
2a Early Concrete operational
2a/2a Middle concrete operational
2b late concrete operational
2b/3a Mature concrete or translational to formal operational
3a Early formal operational.
3b Formal operational

Data in Tables 1 and 2 reveal that:

1. The text book used in RCSQIE to facilitate independent study so as to aid comprehension was assessed and categorised as belonging to level 12, a normal text, and not difficult to use for 17 year old students and thereabout.

2. The experimental category of students that fell in between the 2b level and 3b levels were found to have shifted from 18 students before treatment to 21 students after treatment. The control group recorded a fairly consistent figure without treatment.

Past experience is a basis upon which to learn new material more easily. Durkin (1993) mentioned that a child's ability to comprehend a written discourse is determined by numerous factors some of which are not the product of the school instruction. It goes further to explain that it may happen for instance that a certain child copes successfully with a certain passage not so much because of superior instruction but because of information he or she acquired on his own, interest being a paramount factor. This goes along with the research strategy used in this study by the researchers, allowing the children the pre- reading session to find out information for them. This creates a basis to build upon when the teacher is now giving his own instruction. Concepts and ideas now fall into place and learning is achieved.

Therefore, after treatment, the percentage of students that now fell in between the 2b and the 3b levels in the experimental group showed a slight increase (18-21 students). This can be attributed to the indirect instruction strategy that was used in this research. The learning environment is arranged by the teacher and an opportunity for student involvement was provided in line with the suggestion by Saskachewan, 1988. This was done by making the students to prepare for the class by reading ahead, noting important points, questions, checking the meanings of new words, etc. These activities helped the students greatly in improving their cognitive skills. The pre- reading helps to prepare the students for the lesson proper by providing the previous knowledge, reading culture is developed and helped to train the student in finding out information for himself.

## Conclusion and Implication

Based on the fact that there was an increase in the number of students that fell between 2b and 3b cognitive levels of the RCSQIE strategy instruction students, a conclusion can be drawn that there is a positive effect of previous knowledge on cognition and comprehension on the chosen content areas in chemistry.

The implication of the above is that extra attention be paid to students by encouraging them to read their chemistry textbooks ahead, identify difficult areas and ask question during instruction. The instruction should be carefully planned and assignments encouraged. The extra attention could be implemented on a daily basis during the preparatory periods in the schools instead of leaving the period for an unplanned reading.

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