

# THE EFFECT OF PREVIOUS EXPERIENCE ON IMPROVING COGNITION, COMPREHENSION AND ACHIEVEMENT OF SELECTED CHEMISTRY STUDENTS IN STEM EDUCATION

**Omole, C. O.**

*School of Science and Technology  
Abubakar Tatari Ali Polytechnic, Bauchi, Bauchi State, Nigeria  
E-mail: catieomole@gmail.com*

**Oloyede, O. I.**

*School of Technology Education  
Abubakar Tatari Ali Polytechnic, Bauchi, Bauchi State, Nigeria*

## ABSTRACT

*The main purpose of the study was to determine the effect of previous experience on student's cognition, comprehension and achievement on STEM Education, by using some selected content areas in chemistry as the area of focus. RCSQIE. Two research questions were investigated and four null hypotheses were tested at the 0.05 level of significance. A quasi experimental design (Non equivalent control group design) was employed of which two Schools was picked for the study from Jos north local government area of plateau state. Two groups consisting of forty students each from intact classrooms were used for the study of which one was used for the control group and the other was used as the experimental group. The target population was SSS II students. Three instruments were used for the data collection and a treatment was administered only to the experimental group. Both groups were handled by research assistants. The instruments were validated and a reliability value of 0.89 was established by the Kuder Richardson formula. The results showed that there was a significant difference between the experimental and the control groups post test results, which goes to show that RCSQIE as an instructional strategy had a positive impact in improving the cognitive levels and achievement of the students which could prove useful in aiding STEM education. Among the recommendations made was that teachers should go an extra mile to encourage students to read ahead, ask questions and form notes on their own to improve comprehension.*

**Keywords:** *Previous experience, cognition, comprehension, stem education, chemistry, students*

## Operational Definitions

**2b (A Child Classified as being a late concrete operator):** The Concrete operational stage is the third of four stages of cognitive development in Piaget's theory. This stage, which follows the Preoperational stage, occurs between the ages of 7 and 12 years and is characterized by the appropriate use of logic. Children in this stage can only solve problems that apply to actual (concrete) objects or events, and not abstract concepts or hypothetical tasks.

**RCSQIE:** An acronym for an instruction strategy developed by the researcher, which involves Reading, Comprehension monitoring, Summarizing, Question generation, Instruction and Evaluation.

**Previous Experience:** The RCSQIE makes up the previous experience

**Syllable:** A unit of pronunciation in a word e.g concept (con cept) has two units or two syllables.

**STEM:** Science, Technology, Engineering and Mathematics.

## INTRODUCTION

Cognition can be natural or artificial, conscious or unconscious. Within 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". If a programme is to be judged educationally useful, two conditions apply and these are that it works, which requires empirical evidence which is educationally as well as statistically significant; and that the programme can be justified on philosophical grounds, which requires that its content be described in appropriate detail and its inclusion in a curriculum defended by reasoned argument.

Understanding the language of the content areas (topics being taught) is essential to student's comprehension and achievement. 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 the expository texts even when the topic is unfamiliar and the reading is demanding (Alexander and Kulikowich, 1991; Barton, Heidema and Jordan, 2002). 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). Student's 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).

The use of textbooks is a significant part of the instructional strategy to facilitate comprehension. It has 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). Textbooks should at every step be related to what is being done in the class. The emphasis here is that for comprehension to be achieved relevant books should be recommended and these are those books, which present concepts in a comprehensible manner and explain the nature of the development of corresponding mental structure sequentially. This will allow for the idea being passed across easier to achieve. In view of this, using standard instruments to assess these text books like the Fry's readability graph will not be out of place. This will help in recommending books which are relevant to the level of the student in order to facilitate comprehension.

Some popular study strategies, such as prediction and PQ4R (Preview, Question, Read, Reflect, Recite, Review) have been researched. Many of these monitoring, fix-up, and other reading comprehension strategies are highlighted in the literature review. These kinds of programs are called Cognitive Strategy Instruction (CSI). This study therefore is a carefully worked out plan on finding

out the effect of previous experience on improving the cognition, comprehension and achievement of students in STEM Education, using some selected chemistry concepts as the area of concentration.

The main purpose of the study was to determine the effect of previous experience on student's cognition, comprehension and achievement on STEM Education, by using some selected content areas in chemistry as the area of focus. RCSQIE (Reading, comprehension monitoring, summarizing, question generation, instruction, and evaluation) makes up the previous experience. Based on the above, the following questions were investigated.

- (i) What is the Fry's readability levels for the text book used in RCSQIE to facilitate comprehension?
- (ii) What is the percentage of the students that fall between the late concrete operational and the formal operational reasoning levels before and after treatment?

In response to the above questions, the following tentative answers were formulated for the study and tested at 0.05 level of significance.

**Ho<sub>1</sub>:** There is no significant difference between the mean pre- test chemistry achievement scores of the students that participated in the RCSQIE strategy intervention and the students that undertook a normal classroom instruction.

**Ho<sub>2</sub>:** There is no significant difference between the mean pre- and post- test achievement scores of the students that undertook the RCSQIE strategy instruction.

**Ho<sub>3</sub>:** There is no significant difference between the mean pre- and post-test achievement scores of the students that took part in the normal classroom instruction.

**Ho<sub>4</sub>:** There is no significant difference between the mean post- chemistry achievement test results of the RCSQIE strategy instruction students and the normal classroom instruction students.

The result of this study will go a long way in improving student's comprehension of concepts and subsequently improve cognitive levels, achievement and general performance in Chemistry which is used in his study, Sciences in general, Technology, Engineering and Mathematics Education. It is hoped that students will now be exposed to methods of revealing concepts embedded in textual materials, and be able to engage in a lot of independent study. The independent study includes application of reading skills that represent a flow visible through organizing text information, organizing, and summarizing passages into usable quantum of knowledge. On the part of the Government, there is therefore a need to establish a policy and develop the culture of producing textbooks which are designed with both the financial and cultural context, as well as other realities of the local classroom in mind. In this way, the books can be expected to encourage the students to play active

parts in the learning process, make learning a pleasurable experience and also help to make preparation of the lessons easy for the teachers. Education policy makers in Nigeria and Authors are faced with this task.

The study was delimited to Government Senior Secondary Schools in Jos North Local Government Area of Plateau State. The SSS II classes were used as the subjects for the study as they are not new to the subject and are not under the pressure of facing an external examination. The topics covered were the mole concept, Avogadro's number, and molar volume of gases.

## METHODOLOGY

This study utilized the nonequivalent control group design (Campbell and Stanley, 1963; Sambo, 2005) with a pretest and a posttest. It is a method that uses the existing classrooms in a school for study and does not disrupt the normal school setting for the purpose of creating the desired groups. A control and an experimental group are involved in the study of which treatment is administered to the experimental group only. Both groups are administered with the pre- and post- tests. The area of study was located in Jos North Local Government Area of Plateau state, which comprises of twenty Government senior secondary schools.

The overall target population for the study were all the 2,600 SSS II students offering chemistry in the twenty senior secondary schools in the Jos north local Government area. Only Government schools were selected for the study because they are run by the same body and have a similar administration governing the school. Two schools were selected for the study. One was used as the experimental group while the other was used as the control group. Three instruments used for collecting data collection for the research are as follows:

- The Fry's Readability graph: (An adopted instrument) Teachers would often like to check the readability of materials to be used by their students. Edward Fry, formerly of the Rutgers University Reading Center created one of the most widely used and easy to use readability graphs for Educators
- The Chemistry Achievement Test (CAT): (Developed by the researcher) The chemistry achievement test (CAT) is a twenty item chemistry achievement test developed by the researcher (see appendix D), aimed at testing student's comprehension of specific taught contents.
- Science Reasoning Task II (SRT II test): on Volume and heaviness. (An adopted instrument) . The test focuses on the intellectual development of a child. The Science reasoning task was designed to enable teachers and others estimate the cognitive developmental levels of a student in a class/group (In Piagetian terms).

Eighty students were the total number of SSS II science students used for both the experimental and the control groups from two schools. However, 40 students were used in the experimental and another 40 as the control group,

as intact classes were used. In both the experimental and the control groups, the teachers were tutored on the handling of their various classes. The SRT II and the CAT were administered as pre- and post tests for both the experimental and the control groups. The Fry's readability graph had already been used in the pilot study to test the difficulty level of the text to be used. This was done by the researcher. The treatment was administered to the experimental group. 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 instructed to make their individual observations and record. They were arranged in groups of five and allowed to answer the questions that followed in sixty minutes. The CAT was then administered for one hour, ten 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 and concept mapping, along with the lecture methods. In the fourth week; the SRT II and the CAT were re-administered.

Data collected was 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 individual observations and record. They were arranged in groups of five and allowed to answer the questions that followed in sixty minutes. The CAT was then administered for one hour, ten minutes. RCSQIE was not administered to the students. They were then made to follow a schedule given to the research assistant. In the fourth week; the SRT II and the CAT were re-administered as post tests. Data collected was then collected and analysed. For the study, inferential and descriptive statistics were used to answer the research Questions and hypotheses. Question 1 was answered by using a graph. The hypotheses 1-4 were analysed by using the t- test at the 0.05 level of significance.

## RESULTS AND DISCUSSION

**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:			
Age	17		

Suitable as a normal Text.

The purpose of this research question was to find out the Fry's readability level of the textbook used to facilitate the RCSQIE. To answer this research question, the Fry's readability graph was used. The result is summarized on Table 1. It was applied to the Senior Secondary School Chemistry by Osei Yau Ababio, which was the book recommended to be used in RCSQIE. The pages analysed were pages 29, 154 and 394. In page 29, it was found to have four sentences and one hundred and seventy- three syllables in the chosen hundred words. Page 154 had five sentences and one hundred and sixty-three syllables. Page three hundred and ninety-four had four sentences and one hundred and forty- eight syllables. The average sentence length is 4.3 and the average syllables are 161.3.

The SRT (Science Reasoning Task based on Piagetian principles) identified the number of students in the class that fall in between the 2b and the 3b level or category in the Piagetian terms. 18 of the experimental students fall into this category before treatment. The remaining 22 students fell into the preoperational, early concrete operational, or the middle concrete operational stages. For the control group, 14 of the control group students fall between the 2b level and the 3b category. The remaining 26 fell into the preoperational, early concrete operational, or the middle concrete operational stages. After treatment which was administered to only the experimental group, a slight difference was observed. 21 of the experimental group students now fell in between the 2b and 3b levels while 14 was maintained for the control group category.

An on-line statistical package found on the on-line Concepts and applications of inferential statistics was used to analyse the data. The data to test this hypothesis are presented on Table 2 and case I. From the table, the t-cal was -0.05. The t-crit was 1.9901 at 0.05 level of significance and degree of freedom of 78. Since t-calculated (t-cal) < t-critical (t-crit), the hypothesis is therefore accepted that there is no significant difference between the pre-test achievement scores of the experimental and the control groups.

**Table 2:** t-test analysis of the experimental and the control pre- tests

Cases	Mean	N	STD. Dev	STD. Error	d.f	t.cal	t.crit
I. Exptal	7.375	40	1.6716	0.2643	78	-0.05	1.9901
Control	7.4	40					
II.Exptal	7.15	40	0.9922	0.1568	78	-4.67	1.9901
Control	10.075	40					
III.Exptal	7.1	40	1.502	0.1818	78	1.07	1.9901
Control	6.4	40					
IV.Exptal	10.075	40	2.320	0.3668	78	5.87	1.9901
Control	6.4	40					

The data to test this hypothesis is presented in Table 2 Case II. The pre- and post- experimental test means are 7.15 and 10.075 respectively. This was further subjected to a t- test and the t-cal was found to be -4.67 with a df of 78. The t-crit was 1.9901. The t-cal value was found to be greater than the t- crit and so the hypothesis was rejected. There is therefore a significant difference between the mean pre- and post- test scores of the experimental

group. The data to test this hypothesis is presented in Table 2 case III. The pre- and post- test means of the control group are 7.1 and 6.4 respectively. This was further subjected to a t- test and the calculated t- was found to be 1.07 with a df of 78. The t-crit was 1.9909. The t-cal value was found to be less than the t- crit and so the hypothesis was accepted. The hypothesis is therefore accepted as stated. There is therefore no significant difference between the mean pre and post- test scores of the control group. This was further subjected to a t- test and the calculated t- was found to be 5.84 with a df of 78. The t-crit was 1.9901. The t-cal value was found to be greater than the t-crit and so the hypothesis was rejected. There is therefore a significant difference between the mean post- test scores of the experimental and the control groups.

The first step in this research work was to assess the text book that was going to be used in RCSQIE to assist the students in comprehending the subject matter. This was done by using the Fry's readability graph, in order to assess the readability of the text book in question (New School Chemistry by Osei Yaw Ababio) and the conclusion was that the text was suitable as a normal text. In other words, it was not found to be difficult. This suggests that a student can easily read and understand such a text book as his own study material. When a student is encouraged to engage in independent study, their convergent thinking skills of which one is recalling details and skills which require gaining meaning from written materials is awakened.

The experimental set of students in this study were engaged in pre - reading before the actual lesson took place. This provided them with some previous knowledge before the proper lesson. Stone (1978) identified students who use their past experience (for example, the experimental set of students), as students who use past experiences for complex principles as those used in formulas, chemical activities, etc. The findings of this research shows that the previous knowledge of the experimental students (acquired from the pre-reading) aided their comprehensive ability compared to the control group, of which such an activity was not engaged upon. This can equally be applied to STEM education to improve comprehension of concepts. Past experience is a basis upon which to learn new material more easily. Durkin (1978) 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 research by the researcher, allowing the students in the pre- reading session to find out information for themselves. 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. 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, and noting important points, questions, checking the meanings of new words, etc. These activities helped the students greatly in improving their cognitive skills. Cognitive abilities are those that allow discovery, recognition and comprehension of information. Teachers are faced with the uniqueness of learners and are confronted with the problem of how to help each person develop abilities at the highest possible intellectual level. Unfortunately, our educational system focuses so much on cognition, memory and convergent productions which are identified as the lowest levels of thinking (Guilford, 1956 and Pinnet, 1992).

It was found out that there is a significant difference between the pre- and the post test achievement scores of the experimental group. This shows that once a student that is not intellectually, psychologically and physically impaired, is fit, and can read with a motivational purpose of problem solving to meet intellectual demands, the student is bound to achieve positively. Science and technology students can be motivated to improve cognition. Cognition involves perceiving, reasoning and conceiving. In the primary schools pupils are usually engaged in a lot of cognitive developmental activities e.g quantitative, aptitude and verbal reasoning. This develops their reasoning skills. As we get older, recalling what has been read becomes important. Cognition strategies refer to the ways in which we take in, store and retrieve information.

Generally, different sciences call for different emphasis. STEM education places emphasis on definitions, measurements, manipulations and visualizations (Observation). A mathematical background will go a long way in assisting in problem solving. RCSQIE introduces a pattern of conveying ideas; from the pre-reading to the instruction and then to evaluation. In the pre-reading session, the strategy includes the development of Reading skills, Comprehension monitoring skills, Questioning skills, note taking skills, Improvement of individual inquiry, drawing inferences from contents, recalling of meanings. The instruction includes concepts being taught established methods like Concept mapping, Stressing relevant attributes, Stressing irrelevant attributes, Establishing examples and non examples, Problem solving topics by verbalizing the problem, emphasizing key words, then analyze.

The Evaluation is by testing achievement. The pre- reading helps to prepare the students for the lesson proper by preparing some kind of previous knowledge. The reading culture is developed and helps to train the student of finding out information for himself. The result of question one gave the Fry's

readability level of the Text book used in the study as 12 and the age as 17, and the conclusion was that the book was suitable as a normal text. After a text has been assessed by the teacher and seen to be suitable enough for the students use, the student can now be encouraged to do a lot of independent study with a little guidance.

## CONCLUSION

In a classroom setting, a fraction of them may have comprehension problems and could be assisted to comprehend better by introducing interventions to improve comprehension skills. Children taught haphazardly without any form of planning or direction usually face problems that eventually hinder comprehension and cognition (data processing) especially in Science, mathematics and technology subjects. When dealing with students especially at the secondary school level, the reasoning level of the student should always be considered by the teacher. Many of the students at this level are concrete operators and learn better through direct experience.

This is the more reason why the student should be involved in his own self development. Individual study using recommended textbooks assessed by the teacher and recommended to the students could prove useful. This should be done topic by topic. The idea of sticking to a particular text does not arise. RCSQIE which involves reading, comprehension monitoring, summarizing question generation by the students, then instruction, followed by evaluation could be a way of improving students' comprehension skills. During instruction, other methods could be explored apart from the frayer model and concept mapping as highlighted in the research, depending on the topic in question.

## REFERENCES

- Ababio O. Y.** (2001). *New School Chemistry for Senior Secondary Schools* (3rd Edition) Onitsha: African Fep. Publishers.
- Alexander, P. A., and Kulikowich, J. M.** (1991). Domain knowledge and analogic reasoning ability as predictors of expository text comprehension. *Journal of Reading Behavior*, 23(2), 165-191.
- Allington, R. L.** (2002). You can't learn much from books you can't read. *Educational Leadership*, 16-19.
- Barton, M. L., Heidema, C., and Jordan, D.** (2002). Teaching reading in mathematics and science. *Educational Leadership*, 60(3), 24-28.
- Bean, T. W.** (2001). An update on reading in the content areas: Social constructionist dimensions. *Reading Online*, 5(5). Retrieved May 6, 2004 from <http://www.readingonline.org/articles/handbook/bean/index.html>.

- Comprehensive Strategies** (2008). Educational help website *webstactics*.
- Durkin, D.** (1978). Teaching them to read, Massachusetts pp 417,418, 455
- Guilford, L.** (1956). The structure of the Intellect. *Physiological Bulletin*,53. 267-293
- Meltzer, J.** (2001). *Supporting adolescent literacy across the content areas: Perspectives on policy and practice*. Washington, D.C.: Office of Educational Research and Improvement.
- Pinnet, M.** (1992). A Primer on teaching higher order thinking in intro geology courses . *Journal of Geo-sciences Education* 40, 293-301.
- Sambo, A. A.** (2005). *Research Methods in Education*. Ibadan: Evans Publishers.
- Saskachwan, K.** (1988). *Understanding the Common essentials of learning*.
- Smith, F.** (1982). *Understanding reading* (3rd ed.). New York: Holt, Rinehart & Winston.
- Snow, C.** (2002). *Reading for Understanding: Toward an R&D Program in Reading Comprehension*. Santa Monica, CA: The RAND Corporation.
- Stone D. R.** (1978) *Educational Psychology Development of teaching skills* Pp10.
- Webtactics, F.** (2008). Reading Comprehension. Htm (871)280-286.
- Wright, E. L.** (1998). The academic language of college-bound at-risk secondary students: Self-assessment, proficiency levels, and effects of language development on instruction. *Dissertation Abstracts International*, 58 (10), 3909A. (UMI No. 9812098)