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What Effects Do Cognitive Reasoning Ability and Prior Exposure to Content have on Upper Basic Two Students' Retention in Basic Science?

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Authors' contributions

This work was carried out in collaboration between both authors. Author APD managed the experiment, collected the necessary data and wrote draft of the entire work. Author EEA carried out data analysis, managed all technical sections including design of the study and editorial works. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study addressed the effects of cognitive reasoning ability and prior exposure to content on Upper Basic two (8^{th} grader) students' retention in Basic Science. This focus was necessitated by the persistent poor performance in science generally and inability to meet up with the 60:40 ratio in students' admission into tertiary institutions in Nigeria.
Study Design: The study utilized a pre-test post-test quasi-experimental design; it was a non equivalent control group type.
Place and Duration of Study: Plateau state of Nigeria between April and June, 2012.
Methodology: The instruments that were used to collect data were Basic Science Achievement Test (BSAT) and Science Reasoning Tasks (SRT). The reliability of BSAT was determined using the Kuder Richardson 21($K\text{-}R_{21}$) formula and found to be 0.89 while that of SRT II using test retest approach was found to be 0.81.
Results: It was found that prior exposure of students to contents of basic science significantly

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improved retention. Similarly, knowledge retention of high and low reasoning ability level students significantly differed in favour of high ability students. The study also found that male and female basic science students exposed to content prior to instruction do not differ significantly in their knowledge retention. However, there was a significant interaction effect of method, sex and reasoning ability on students' retention in basic science.

Conclusion and Recommendation: It can be concluded that prior exposure to content enhanced students' retention and that high ability students retained more of science learnt compared to low ability student. Prior exposure to content favoured both male and female students' retention. It is recommended that authors of methodology text books should include and explain carefully how prior knowledge of content can be used to enhance retention of learnt materials. Basic science teachers should be made to be aware of the relationship that exists between reasoning pattern of learners, conceptual demand of the school subject and the methods of teaching that will facilitate retention, among others.

Keywords: Basic education; prior exposure to content; basic science; cognitive reasoning; retention; gender.

1. INTRODUCTION

Basic science is one of the core subjects in the Junior Secondary School (7th to 9th grade) in Nigeria. As a science subject in the secondary school, it provides the basic and functional knowledge that is necessary for the understanding of scientific principles and concepts by 8th grade students at Senior Secondary School level. Basic science occupies a unique position in the school curriculum, as it equips students with the skills necessary to build a progressive society and it also forms the bedrock upon which further science studies rest. It is a course that integrates students into the world of science after being exposed to the rudiments of science called, primary science at the primary school level [1,2].

Research reports have revealed that graduates of integrated/Basic science leave much to be desired in terms of their achievement in JSSCE examinations [3-5]. For the past two decades, students' achievement in that are part of nearly every human action. Cognitive abilities are brain-based skills we need science subjects is consistently reported to be very low [2,6-8]. A survey of the JSSCE results of plateau state for five years (2004-2008) revealed that students' performance is very poor.

The performance of students in integrated science in JSSCE from 2004 to 2008 in Plateau State has not been very impressive. For the five years under consideration, the percentage pass at distinction level is less than 5% and also the percentage pass at credit level has never exceeded 24% with the exception of 2005 with 52.54% credit pass (see Table 1). This could be a reflection of the fact that the students have not demonstrated the necessary cognitive reasoning skills needed for good performance and retention of what had been taught and learned in their three years of junior secondary school. It could even be that the appropriate teaching strategy was not used or worse still that the students were probably not taught the required integrated science concepts.

Researchers have begun to question the role of cognitive reasoning ability of students in meaningful learning and retention in science subjects. To Achor [9] the learners' level of cognitive style, thinking and reasoning is a major determinant of achievement. Nkwo, Akinbolola and Edinyang [10] and Akpan [11] identified the developmental level of the learner in terms of chronological and cognitive maturity as a major determinant of achievement too. There is, therefore, the need to direct efforts at analysing the reasoning ability of the learners vis-a-vis the instructional strategy that would be appropriate for all ability groups in the classroom by science teachers [12]. Kurtz and Karplus [13] define cognitive reasoning ability as cognitive processes by which people start with information and come to conclusions that go beyond that information. Cognition has to do with how a person understands and acts in the world. It is the set of abilities or processes to carry out any task from the simplest to the most complex. They have more to do with the mechanisms of how we learn, remember, problem-solve, and pay attention rather than with any actual knowledge. For instance, answering the telephone involves at least: perception (hearing the ring tone), decision taking (answering or not), motor skill (lifting the receiver), language skills (talking and understanding language), social skills (interpreting tone of voice and interacting properly with another human being) [14].

According to Piaget [15] four levels of cognitive reasoning exist. However, only two of these stages of cognitive reasoning are said to be relevant to secondary school students. These are the concrete thought pattern and formal thought pattern [16]. The concrete and formal thought pattern as categorised by Piaget starts from the age of 11-above. Hence, it is on that basis that the last two stages are relevant to the present study. Resnick [17] observes that the formal operational stage of Piaget could further be categorised into two. The categorisations are: Lower order reasoning kills and higher order reasoning skills.

To Resnick lower order reasoning involves ability to read, write and collect information, while higher order reasoning involves categorising and analysing information, drawing conclusion, problem solving, determining cause and effect, evaluating options, planning and setting goals, decision making and reflecting on one's own progress. Resnick's categorisation seems to be anchored on Blooms taxonomy.

According to Bloom [18], in the taxonomy memorization and recall of information are classified as lower order thinking or reasoning, while application, analysing, synthesising and evaluating are classified as higher order reasoning. The categories in the cognitive domain (with outcome-illustrating verbs) are:

1.1 Knowledge

Remembering of previously learned material; of terminology; specific facts; ways and means of dealing with specifics (conventions, trends and sequences, classifications and categories, criteria, methodology); universals and abstractions in a field (principles and generalizations, theories and structures). Knowledge is (here) defined as the remembering (recalling) of appropriate, previously learned information. Illustrating verbs include defines; describes; enumerates; identifies; labels; lists; matches; names; reads; records; reproduces; selects; states; views; writes.

1.2 Comprehension

Grasping (understanding) the meaning of informational materials. Illustrating verbs include classifies; cites; converts; describes; discusses; estimates; explains; generalizes; gives examples; illustrates; makes sense out of; paraphrases; restates (in own words); summarizes; traces; understands.

1.3 Application

The use of previously learned information in new and concrete situations to solve problems that have single or best answers. Illustrating verbs include acts; administers; applies; articulates; assesses; charts; collects; computes; constructs; contributes; controls; demonstrates; determines; develops; discovers; establishes; extends; implements; includes; informs; instructs; operationalizes; participates; predicts; prepares; preserves; produces; projects; provides; relates; reports; shows; solves; teaches; transfers; uses; utilizes.

1.4 Analysis

The breaking down of informational materials into their component parts, examining (and trying to understand the organizational structure of) such information to develop divergent conclusions by identifying motives or causes, making inferences, and/or finding evidence to support generalizations. Illustrating verbs include analyzes; breaks down; categorizes; compares; contrasts; correlates; diagrams; differentiates; discriminates; distinguishes; focuses; illustrates; infers; limits; outlines; points out; prioritizes; recognizes; separates; subdivides.

1.5 Synthesis

Creatively or divergently applying prior knowledge and skills to produce a new or original whole. Illustrating verbs include adapts; anticipates; collaborates; combines; communicates; compiles; composes; creates; designs; develops; devises; expresses; facilitates; formulates; generates; hypothesizes; incorporates; individualizes; initiates; integrates; intervenes; invents; models; modifies; negotiates; plans; progresses; rearranges; reconstructs; reinforces; reorganizes; revises; structures; substitutes; validates.

1.6 Evaluation

(could be same level as synthesis): Judging the value of material based on personal values/ opinions, resulting in an end product, with a given purpose, without real right or wrong answers. Illustrating verbs include appraises; compares & contrasts; concludes; criticizes; critiques; decides; defends; interprets; judges; justifies; reframes; supports [18].

This implies that most of the classical scientific inquiry skills expected of secondary school students such as formulating hypothesis, planning experiments and drawing conclusions are also classified as higher order thinking skills. This appears to be a pointer to why most students find science teaching and learning difficult. This study therefore adopts Resnick's categorization since this categorisation accommodates both the lower and higher order reasoning as identified by Bloom's taxonomy.

The integrated/basic science curriculum [19] outlines a number of objectives for integrated science teaching. Specifically, it states the following as the overall objectives of the curriculum; that the integrated science students should be able; to develop interest in science and technology, acquire basic knowledge and skills in science and technology, apply their scientific, technological knowledge and skills to meet societal needs, take advantage of the numerous career opportunities offered by science and technology and become prepared for further studies in science and technology. These objectives require that students' reason at the Piagetian formal reasoning level which is usually from 12 years to adolescent. At the period of formal operations, the child's thought process becomes quite systematic and reasonably well integrated. The child reasons (thinks) formally, logically and understands from one situation to another [20]. This implies that reasoning at this level is at higher order. Whether or not junior secondary two students reasoning skills are as expected is an issue that needs to be determined empirically.

Students need to develop both content knowledge and transferable reasoning skills. In similar manner as prior exposure to objectives, it is hypothesized in this study that prior exposure to contents would facilitate teaching of the subject and therefore learning also. By prior exposure, it is meant that contents of what is to be taught by the teacher are presented to learners ahead of time for interaction. Learners are inquisitive, so any content given to them in preparation to incoming lessons could be read ahead of time. The effect is expected to reflect in the final results from the achievement/retention test. This can only be achieved if a balanced method of teaching is introduced. This study examines the reasoning ability of students and how each ability level relates to their retention in Upper Basic two Science. It also seeks to evolve instructional strategy that could help improve on the reasoning ability of the students and therefore improve their retention.

Retention is the ability of the mental structure of an organism to keep that which is given over a long period of time. Long-term memory (LTM) is the final stage of the dual memory, in which data can be stored for long periods of time. While short-term and working memory persists for only about 20 to 30 seconds, information can remain in long-term memory indefinitely. Retention therefore is only possible with the presence of long term memory. According to Mazur [20], long-term memory has also been called reference memory, because an individual must refer to the information in long-term memory when performing almost any task.

Gagne [21] believes that learning is only meaningful when what is learnt can be retained over a time. That is to say that retention is the ability to remember facts, principles, concepts, themes, and so on already learned. Retention is generally determined by the quality of information recalled.

Three theories were considered as foundational to this study. They are Piaget's constructivist theory of 1977, Jerome Bruner's theory of Discovery Learning in 1960 and Ausubel's 1968 theory of meaningful learning. To Piaget [22] learners construct knowledge for themselves. Each learner individually (and socially) constructs meaning as he or she learns. In the words of Hein [23] the consequences of the constructivist view are two folds: We have to focus on the learner in thinking about learning (not the subject/lesson to be taught); there is no knowledge independent of the meaning attributed to experience (constructed) by the learner or community of learners.

Jerome Bruner's theory of learning focuses on the importance of the discovery learning method to instruction. Bruner [24] contends that there are two forms of discovery learning which are; assimilation and accommodation. He further states that learning is greatly promoted when the learner is able to find out things for himself and that the learner does that when the learner's cognitive structure (learner's existing structure of knowledge) is already tuned to absorbing the new information discovered simply by assimilating it.

The constructivist theory requires that the attention of teachers be turned back to the learners each of whom creates his or her own model to explain nature to them. According to Piaget [22] the constructivist teacher is required to follow a pedagogy that must provide learners with the opportunity to: Interact with sensory data; Construct their own world. This study achieved this by presenting the learning content to students in form of modules prior to instruction. The learning difficulties of learners could also be conceived in terms of their mental readiness and their prior experiences. It is in recognition of this that Ausubel [25] theorised that prior knowledge of the learners should be a major consideration when planning a teaching learning instruction. Ausubel further maintains that to take care of the learning needs of the learners, teachers should make use of advance organisers. He describes advance organizers as things that the learner can use to stimulate or facilitate learning. In this case, it is prior exposure to content. Therefore, as learners interact with sensory data and construct their own world through the use of advanced organisers, learning becomes greatly promoted when the learner's cognitive structure (learner's existing structure of knowledge) is already tuned to absorbing the new information discovered simply by assimilating it.

This research study contributes to an informed understanding and new knowledge of the cognitive reasoning ability and prior exposure to content retention in Basic Science in 8th Grade children that has major implications on pedagogy, didactics, assessment and remedial support to learners who are encountering challenges in mastery and acquisition of skills. Science subjects are gateway subjects to acquiring cognitive reasoning and the analysis and interpretation of content aids in students acquiring skill sets that are needed for later success in schooling and tertiary education.

2. PURPOSE OF THE STUDY

The purpose of this study is to find out the effects of cognitive reasoning ability and prior exposure to content on students' retention ability in Basic science in Plateau State of Nigeria. Specifically this study sets out to:

i. Determine the effect of exposure to content prior to instruction on JSS II students' retention in Basic science.
ii. Find out the effect of prior exposure to content on male and female students' retention in Basic science.
iii. Determine the effect of prior exposure to content on high and low reasoning ability students' retention in Basic science.

3. RESEARCH QUESTIONS AND HYPOTHESES

The following research questions were answered:

i. To what extent do the students exposed to content prior to instruction and those that were not differ in their retention in Basic science?
ii. To what extent do male and female students exposed to content prior to instruction differ in their retention in Basic science?
iii. To what extent do low and high reasoning ability groups with prior exposure to content differ in their retention in Basic science?

The following null hypotheses guided the study.

i. There is no significant difference in the retention mean scores of Basic science students exposed to content prior to instruction and those that were not.
ii There is no significant difference in the retention mean scores of male and female Basic science students exposed to content prior to instruction.
iii. There is no significant difference in the retention mean scores of high and low ability Basic science students exposed to content prior to instruction.
iv. Interactions among groups, ability and sex have no significant influence on students' retention in Basic science.

4. MATERIALS AND METHODS

4.1 Design

The study utilized a pre-test post-test quasi-experimental design. This design was selected due to the fact that random assignment of subjects to treatment groups was not possible. This is because the research was conducted in a school setting and as observed by Achor and

Ejigbo [26], some classrooms situations do not lend themselves to excessive manipulations, therefore intact groups was used. The study was a non equivalent control group quasi-experimental design type.

4.2 Population

The population for the study is all the Upper Basic II students in Plateau State central education zone and the population of all the upper basic II students is 14469 as at 2012. The choice of upper basic II students is based on the fact that the class is not preparing for an external examination at this level. The students are expected to have been exposed to basic science concepts at the upper basic I level to give them a rich knowledge base in terms of reasoning ability. Another consideration for the choice of the class is that at this stage the students are expected to have reached the formal level of reasoning, consequently, they should be able to understand the concepts in their basic science syllabus most of which require formal reasoning.

4.3 Sample and Sampling

The sample for the study was selected from a population of 14469 upper basic II students distributed among 106 Upper Basic schools in Plateau Central education zone. The sample was selected from the population using the Yaro Yamane formula which is $n=N/(1+Ne^2)$ Where n = sample size, N = the finite population and e = level of significance = 0.05N = 14469/1+14469(0.05)2 n = 389 approximately.

However a sample size of 418 was used in the study, made up of 204 male students and 214 female students, being a quasi experimental study to accommodate the students in the sampled classes. The sample size of 418 is considered adequate since it is an experimental type where emphasis is not on large sample size but the treatment and control of extraneous variables.

The study employed purposive and simple random sampling techniques in the selection of the sample. It is purposive because to ensure precision and control, the researcher selected six comparable schools out of the 106 schools in Plateau central education zone. To do this adequately, the researcher first itemized some factors as the criteria that guided in the selection of the schools. These criteria are: School should be a public school, the school should be co-educational, the school should have at least two arms of upper basic II and that the school uses the National core curriculum/National Examination Council syllabus on basic science. Also the school should have at least one qualified basic science teacher with a minimum of first degree in integrated science, biology, chemistry or physics education and also with a minimum of 3 years post qualification experience, have laboratory facilities, have at least two periods of basic science per week and must have presented students for Junior Secondary School Certificate Examination (JSSCE) for not less than 5years. Base on these criteria, only 78 schools qualified for consideration out of which six were drawn.

The researcher's decision to use government secondary schools and not private schools is because the former have in the recent past been affected by rampant strike actions and therefore they may not be comparable with the later in terms of syllabus coverage. Experience also shows that students in government controlled schools are not placed in the schools on the grounds of their common entrance examinations. Such examinations are not strictly used for placement because the state government has an obligation to provide education to children, particularly at the primary and secondary school levels. What is obtained in private and unity schools is different. In these private and unity schools students are admitted based on high scores in common entrance examination.

The simple random sampling technique was employed in selecting six secondary schools out of the 78 secondary schools, using the "hat and draw" method. To do this effectively, the researcher listed the 78 comparable schools within the population serially to get a sampling frame. The names of the selected secondary schools in the central education zone were written on pieces of paper which was folded and placed in a "hat". The pieces of paper were well mixed and one of them was picked. The name of the school picked was recorded as one of the units to be included in the sample. The same procedure was adopted in selecting five other schools.

Table 1. Students' performance in Junior school certificate examination (JSCE) integrated science from 2004-2008 in Plateau State

Year	Enrolment	A	%	C	%	P	%	F	%
2004	19617	474	2.42	4011	20.44	13257	67.58	1875	9.56
2005	24601	960	3.90	12926	52.54	9413	38.26	1302	5.30
2006	28019	732	2.61	5170	18.45	14696	52.45	7421	26.49
2007	32794	297	0.91	4192	12.78	20171	61.51	8134	24.80
2008	43470	683	1.57	9672	22.25	25266	58.12	7849	18.06

Source: Plateau State Ministry of Education, Area Directorate Offices from 15 LGAs of the State
A=Distinction (70 and above);B =Credit (60-69); C=Merit(50-69); P=Pass (40-49)F=Fail(0 -39)

The schools so selected constituted the sample of upper basic schools for the study. The same procedure was employed to allocate three schools each to experimental and control groups. Similarly, where there were more than two arms in each of the school, hat and draw technique was applied to obtain any two arms.

4.4 Instrumentation

In this section, the instruments for data collection are described. The instruments that were used to collect data were Basic Science Achievement Test (BSAT) and Science Reasoning Tasks (SRT).

4.4.1 Basic science achievement test (BSAT)

The Basic Science Achievement Test (BSAT) was used to test students' achievement basic science. The test was developed by the researcher based on the concepts that were taught. It contains 50 multiple choice items initially and was reduced to 40 items after validation. The multiple choice test was chosen because of its objectivity in marking.

BSAT was used in this study because it was the aim of the researcher to measure the achievement of the students so as to find out how much learning the students acquired. The BSAT covered concepts taught under the following topics; Work, Energy and Power, Simple Machines (Wheel and Axle), Simple Machines (Screw thread), Simple Machines (Gears), Kinetic Theory and Thermal Energy. BSAT consisted of 40 items in multiple choice objectives test. (See appendices B, C and D for the detailed questions, answers and answer sheet respectively).

The BSAT items developed by the researcher were done by first constructing a test blueprint. The blue print has lower reasoning level which connotes the first two categories/levels of (knowledge and comprehension) cognitive domain, while the higher reasoning level refers to reasoning abilities and skills operating in the levels of (application, analysis, synthesis and evaluation) of the cognitive domain. The six levels of cognitive domain are categorised into lower cognitive outcomes and higher reasoning processes because ability progress dimension of the test blue print is statistically evaluated when it is divided into two parts [27].

4.4.2 Science reasoning tasks (SRT)

Science Reasoning Tasks (SRT) was developed by the team "Concepts in Secondary Mathematics and Science at Chelsea College, University of London in 1978. It was developed to investigate the relationship between the optimum Piagetian level at which a pupil can reason and the understanding of science for which he can achieve.

SRT is adopted in this study in order to assess reasoning ability of the respondents. The SRT is made up of 1-7 tasks. Since children are mostly sent to schools early nowadays, most of the upper basic II students are expected to be between 11-15 years. Therefore task II was used for this study and is therefore explained further.

4.4.3 SRT tasks II volume and heaviness

The content of this task include the concept "size" in which mass, volume and density are involved. The task is hierarchically constructed with the first three items testing the lower reasoning ability at the concrete operational level. It has fourteen items altogether with internal consistency of 0.78 and test re-test reliability coefficient of 0.84 [28].

Although the test was developed and trial tested in London, it has been found to be effective in other countries of the world. For instance, Achor [9] used it on Physics students in Kogi State and obtained reliable results. Bomide [29] earlier used the instrument on Biology students in Plateau State and obtained reliability coefficient of 0.85 and 0.67 for tasks II and III respectively from a sample of 135 Upper Basic one students in Jos Metropolis which were considered adequate. And Ozoji [30] used it on JSS III integrated science students in Plateau State and also obtained reliable results.

Each item is scored 0 for a wrong answer and 1 for a correct answer. The number of items correctly answered at each stage determines the reasoning ability of the student. Generally, two-third (2/3) pass criterion is often used. For the purpose of this study, students with scores less than 8 were regarded as low reasoning ability group and those with scores from 8 and above were regarded as high reasoning ability group. The SRT II is made up of 14 items.

4.5 Validation of Instrument and Lesson Plans

One instrument (BSAT) constructed by the researcher and the lesson plans were validated.

4.5.1 BSAT:

A table of specification based on Blooms taxonomy of educational objective and the concepts to be taught was prepared. Fifty multiple choice questions were constructed and effort was made to use simple language in constructing the questions. On each question was marked the level of reasoning ability it was supposed to test. The instrument was given to a science educator (physics bias) from the University of Jos and lecturers teaching integrated science (physics bias) in the Departments of Integrated Science in FCE Pankshin and COE Gindiri. They were asked to check the clarity of expressions, adequacy and relevance of the questions to the objectives they were meant to test as well as the variables under study. Their individual criticisms and contributions led to the reduction of the number of questions to forty and in the reconstruction of some of the questions.

BSAT was trial tested using Upper Basic II Basic Science students from Plateau Southern Education Zone for six weeks of teaching and the results were used to conduct item analysis. The second instrument, the Science Reasoning Tasks (SRT) is a standardized test therefore it was used without validation but its reliability coefficient was determined afresh to be sure of it usability.

4.5.2 Lesson plan

The lesson plan prepared by the researcher and the research assistants was also subjected to face validation. Four physics educators one from the University of Jos, one from FCE Pankshin and two from COE Gindiri were requested to check the lesson plan for grammatical and spelling errors as well as the appropriateness of the lesson plan to the level of the students it was intended for. They were also requested to give constructive suggestions that will enrich the lesson plans. In all, the valuators comments on the instruments indicated the need for grammatical corrections, reordering of the items in BSAT and reconstruction of some items.

From the trial testing the reliability of BSAT was determined using the Kuder Richardson 21($K\text{-}R_{21}$) formula. The reliability of BSAT was found to be 0.89. That of SRT II using test retest approach was found to be 0.81.

4.6 Data Collection Procedure

The teachers whose classes were used for the study were trained as research assistants. The researcher ensured that the research assistants have at least a minimum of a first degree certificate in integrated science, chemistry, physics or biology with at least three years post qualification experience. These research assistants were trained by the researcher using the lesson plans prepared by the researcher and the research assistants and the SRT. The research assistants that taught the experimental group were trained on how to effectively use the lesson plans to teach using prior exposure to content. The researcher used one of the prepared lesson plans on wheel and axle to each using prior exposure to content.

The SRT was administered as pre-test only. The pre-test was administered a day before the commencement of the study. Sampled schools within the same town or location had their test the same day to avoid interaction. The research assistants helped in the administration of SRT. This was to ensure that the students did not copy from each other and that the test scripts were collected from all the students at the end of the test. Results from this pre-test were used for grouping students into different ability groups (that is, high and low ability).

The BSAT was administered as pre-test and post post test (or delayed or retention test) to both the control and experimental groups. The pre-test was administered a day to the start of the treatment, which lasted for eight weeks. The BSAT consisted of 40 objective questions and the students spent a minimum of 1 minute and a maximum of 1.5 minutes on each question. Therefore, the duration of the test was 1hr. The durations of the post post test or delayed test was also 1hour. To avoid a likely problem of students becoming too familiar with BSAT, the questions were reshuffled after each use. The teachers whose classes were used served as research assistants and they taught the students for the eight weeks. They also help in the administration of the instruments. The research assistants served as invigilators. Thus, they helped in distributing the test items and the answer sheets, answering students' questions and ensuring that the students did not copy from one another. Each script and answer sheet were returned at the end of the test. The post post test or delayed test was administered two weeks after post test. Sampled schools within the same town or location did their tests the same day to avoid interference.

5. RESULTS AND DISCUSSION

5.1 Results

The data obtained were analysed with respect to each question and each hypothesis. All the research questions were answered using mean and standard deviation. All the hypotheses were tested using two way Analysis of Covariance (ANCOVA).

5.1.1 Research question one

To what extent do the students exposed to content prior to instruction and those that were not differ in their retention in Basic science?

Examination of Table 2 shows that the pre-test scores of both experimental and control group are almost the same (22.5861 and 22.4713 respectively). The Table also shows that retention (or post post test) scores of the experimental group is higher than that of the control group (41.8361 and 33.4483 respectively). The mean gain of the experimental group was found to be higher than that of the control group (19.25 and 10.977 respectively). The mean gain difference score for the two groups was found to be 8.273 in favour of the experimental group which is appreciably high.

5.1.2 Research question two

To what extent do male and female students exposed to content prior to instruction differ in their retention in Basic science?

Table 3 shows that both male and female students had low mean pre-test scores of 22.7607 and 22.4252 respectively. After exposure to treatment, the retention mean scores of both male and female students were found to be 43.8205 and 40.0079 respectively. This shows that there has been an improvement. The mean gain of the male subjects was found to be 21.0598 and that of the female students 17.5828. The mean gain difference is 3.4771 in favour of the male respondents. This shows that the male students retained more than their female counter parts.

5.1.3 Research question three

To what extent do low and high reasoning ability groups with prior exposure to content differ in their retention in Basic science?

Table 4 reveals that the mean pre-test and post-test scores for high and low reasoning ability students are 23.038 and 22.0526 for pre-test and 43.8231 and 39.5702 for the mean retention score. Their mean gains are 20.7693 and 17.5176 respectively. The mean gain difference

Table 2. Mean and standard deviation for students' retention in BSAT

Method		Pre-test	Retention	Mean gain
Experimental	Mean	22.5861	41.8361	19.250
	N	244	244	
	S.D	7.65974	12.4648	
Control	Mean	22.4713	33.4483	10.977
	N	174	174	
	S.D	8.55089	9.76576	
Mean gain difference		-	-	8.273

is 3.2517 in favour of the high reasoning ability group. This implies that the high reasoning ability students retained more than their low reasoning ability counter parts.

5.1.4 Hypothesis one

There is no significant difference in the retention mean scores of Basic science students exposed to content prior to instruction and those that were not.

The results of the Analysis of Covariance (ANCOVA) of students' retention scores in BSAT presented on Table 5 shows that the difference in the retention mean scores of students exposed to content prior to instruction and those that were not is significant at 0.0001 ($F_{1,\ 417} = 75.618$, $P < 0.05$). The null hypothesis of no significant difference in the retention mean scores of students exposed to content prior to instruction and those that were not was therefore rejected. This implies that prior exposure to content does enhance students' retention in Basic science.

5.1.5 Hypothesis two

There is no significant difference in the retention mean scores of male and female Basic science students exposed to content prior to instruction.

The result of the ANCOVA on Table 6 indicates that the calculated F value for the effect of sex on retention is 4.276 and it is not significant at 0.566 ($P > 0.05$). Therefore the null hypothesis of no significant difference in the retention mean scores of male and female students exposed to content prior to instruction was not rejected. This implies that the retention of male and female students exposed to content prior to instruction do not significantly differ ($F_{1,\ 243} = 4.276$; $P < 0.05$).

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5.1.6 Hypothesis three

There is no significant difference in the retention mean scores of high and low ability Basic science students exposed to content prior to instruction. Data on Table 6 were used to test hypothesis three.

Table 3. Mean and standard deviation of male and female students in experimental group's retention on BSAT

Gender		Pre-test	Retention	Mean gain
Male	Mean	22.7607	43.8205	21.0598
	N	117	117	
	S.D	8.0715	12.6161	
Female	Mean	22.4252	40.0079	17.5827
	N	127	127	
	S.D	7.2883	12.0919	
Mean gain difference		-	-	3.4771

Table 4. Mean and standard deviation of high and low reasoning ability students in experimental group's retention on BSAT

Ability level		Pre-test	Retention	Mean gain
High ability	Mean	23.0538	43.8231	20.7693
	N	130	130	
	S.D	7.9381	12.2097	
Low ability	Mean	22.0526	39.5702	17.5176
	N	114	114	
	S.D	7.3278	12.4239	
Mean gain difference		-	-	3.2517

The results on Table 6 reveals that the difference in the retention mean scores of high and low ability students exposed to Basic science content prior to instruction is significant at 0.05 ($F_{1, 243}$ = 3.770;P ≤ 0.05). Therefore the null hypothesis of no significant difference in the retention mean scores of high and low reasoning ability students exposed to content prior to instruction was rejected. This implies that reasoning ability level does enhance retention of Basic science students exposed to content prior to instruction.

5.1.7 Hypothesis four

Interactions among group, ability level and sex have no significant influence on students' retention mean scores in Basic science.

Data on Table 5 were used to test hypothesis four. Table 5 reveals that the students' retention scores in BSAT have a calculated F value of 4.600 which is significant since 0.033 is less than the probability level of 0.05. Therefore the null hypothesis that there is no significant interaction effect of method, sex and ability level on students mean retention scores was rejected ($F_{1, 417}$ = 4.600; P < 0.05).

5.2 Discussion of Findings

The study sets out to investigate the effects of cognitive reasoning ability and prior exposure to content on students' retention in Basic science. This discussion is based on the analysis and findings on the three research questions and the four hypotheses raised for the study.

It was found that the retention mean scores of students exposed to content prior to instruction was higher than those taught with conventional lecture method. On testing whether the observed difference is significant or not using ANCOVA, it was found that there is a significant difference in the retention means scores of students taught with prior exposure to content and those taught with conventional lecture method. That is to say that prior exposure to content enhanced retention. This is consistent with the finding of Nkwo, Akinbolola and Edinyang [10] and Salman, Yahaya, Yusuf, Ahmed and Ayinla [31]. This significant difference is attributable to the treatment. This implies that prior exposure to content enhances retention in basic science.

The effect of prior exposure to content on the retention mean scores of male and female Basic science students was also a concern in the study. The result revealed that the male students had a slightly higher post- test mean retention scores in BSAT than their female counter parts.

Their post-test mean gain difference was in favour of the male subjects. This difference was not significant as revealed by the analysis of covariance ($F_{1, 243}$ = 4.276; P< 0.05). The obtained result was quite expected as prior exposure to content has been found to be effective in enhancing achievement in both male and female in basic science students. When a method of instruction is exciting and interactive, it does enhance retention.

The finding also shows that the mean gain difference in the post test retention scores of high and low ability group basic science students exposed to content prior to instruction is 3.2517 in favour of the high reasoning ability group. On testing whether the difference is statistically significant, ANCOVA statistics reveals that there is a significant difference in the mean retention scores of high and low ability groups' students on BSAT ($F_{1, 243}$ = 3.770; P < 0.05).

Table 5. Two way ANCOVA of students' retention scores in BSAT

Source	Type II sum of squares	Df	Mean square	F	Sig.
Corrected model	11033.471a	8	1379.184	82.704	.000
Intercept	49808.048	1	49808.048	333.741	.000
Pre test	960.398	1	960.393	151.925	.000
Method	7030.780	1	7030.780	75.618	.0001
Sex	52.641	1	52.641	.009	.924
Ability level	680.787	1	680.787	5.527	0.019
Method*Sex*ability level	566.595	2	566.595	4.600	.033
Error	50382.922	409	123.186		
Total	676002.000	418			
Corrected total	61416.392	417			

R Squared = .180 (Adjusted R Squared =.164)

Table 6. Two way ANCOVA of male and female students retention in BSAT

Source	Type II sum of squares	Df	Mean square	F	Sig.
Corrected model	3066.780a	4	766.695	5.280	.0001
Intercept	33790.725	1	33790.725	232.706	.0001
Pre test	752.282	1	752.706	5.181	.0001
Sex	620.948	1	620.948	4.276	.566
Ability level	547.407	1	547.407	3.770	.050
Sex*ability level	641.553	1	641.553	4.418	.037
Error	34704.663	239	145.208		
Total	464834.002	244			
Corrected total	37771.443	243			

a. R Squared = .081 (Adjusted R Squared = .066)

The study is consistent with that of Nzewi and Osisioma [32] and Sungur and Tekkkaya [33] who found that there is a significant difference between concrete and formal students or high and low reasoning ability students with respect to achievement in Biology. As asserted by Nzewi and Osisioma [32] high reasoning ability students are more naturally endowed with ability to learn faster than low reasoning ability level students. This probably explains why the high reasoning ability level students in the present study retained learnt materials more than their low reasoning ability level counterparts.

The study also sought to find out if interactions among group, ability level and sex had influence on students' mean retention scores in basic science. The result shows that there is significant interaction effect of group, ability level and sex on students' retention in basic science. Thus interactions among groups, ability levels and sex had significant effect on students' retention in basic science. The implication is that exposing students to content prior to instruction can only be combined in a class to teach students of mix sex and abilities with caution since interaction effect is significant.

Thus prior exposure to content was effective for high and low ability level students as well as male and female students. The finding in the study contradicts that of Ogbeba [34] and Nkwo, Akinbolola and Edinyang [10] that found that there are no significant interaction effects of prior knowledge of instructional objectives and gender on the achievement of SSII Biology and Physics students respectively. The fact that ability level was included in the interaction in this study must have accounted for the significant difference and besides the present study focuses on retention and not achievement.

6. CONCLUSION

Based on the findings of the study it was concluded that prior exposure of students to content of basic science significantly improved retention. Similarly, retention of high and low reasoning ability level students significantly differed. The study also concluded that male and female basic science students exposed to content prior to instruction do not differ significantly in their retention.

7. RECOMMENDATIONS

Based on the findings of this research the following recommendations were made.

1. Basic science teachers should expose contents to students prior to instruction as this will go a long way to improve the students' retention.
2. Basic science teachers need to know the reasoning pattern of the learners and the instructional strategy that can be used to ensure retention of learnt materials
3. Basic science teachers should be adequately trained on the use of prior knowledge of content for classroom instruction.
4. Curriculum planners should ensure that the reasoning ability of the learner is considered when designing curriculum materials. Where this is not done, there may be a mismatch between the cognitive level of the learners and the curriculum materials presented to them.
5. Authors of methodology text books should include and explain carefully how prior knowledge of content can be used to enhance retention of learnt materials.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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