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Limitations to Understanding Scientific Concepts and Academic Performance in Primary Science among Primary Six Pupils in Cross River State Nigeria

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ABSTRACT

There are certain factors which can hinder pupils understanding of science concept in the primary school. These factors need to be identified and addressed properly if pupils are to have a sound knowledge of science at that level. This study examined the relationship between limitations to understanding scientific concepts and academic performance in Primary Science among primary six pupils in Cross River State, Nigeria. In order to achieve the set objectives of this study, two hypotheses were formulated and tested. Two instruments were used for data collection. They were limitations to understanding scientific concepts questionnaire (LUSCQ) and a 50-item primary science achievement test. These instruments were validated and administered to 1818 pupils out of 68,201 pupils in 70 schools in the study population. A proportionate stratified random sampling technique was adopted hence; the study area was stratified into three educational zones with different populations. The data obtained were analyzed using Pearson Product Moment Correlation Coefficient (r) statistical tests at 0.05 level of significance. The findings revealed that there is a significant relationship between pupils' perception of scientific language and academic performance. Also the findings further revealed a significant relationship between pupils' pre-experience and their academic performance in primary science. This paper recommends that pupils should be helped to understand the technical terms in science and be exposed to more science experiences in their environment. This will enable them improve their academic performance in primary science.

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1. INTRODUCTION

The issue of improving the quality of education, in particular science education is the most critical reason why 'nature study' which was taught in the primary school has now been replaced with primary science which is more relevant and embracing. Primary science offered in the primary school is the foundation of other science subjects such as biology, chemistry and physics which are offered at the secondary and tertiary levels of education. A proper development of science at the primary school level is the key to successful development of science at other levels of education. But most often pupils fail due to certain limitations. That is why the National Policy on education (2004) rightly stated some of the objectives of primary education to include:

The laying of a sound basis for scientific and reflective thinking; developing in the child the ability to adapt to his changing environment; and to give the child opportunities for developing manipulative skills that will enable him to function effectively in the society within the limit of his capacity [1].

The implication of this is that at the completion of primary education, pupils are expected to be properly exposed to the processes of scientific inquiry to enable them function effectively in the society. They need a sound knowledge of science as well as scientific attitude to enable them face the challenges of science and technology in the rapidly changing society. But where the foundation is faulty, there is a need to address the problem in order to help the pupils to achieve success in their academic pursuit.

Science generally is very relevant in the daily life of the pupils as they progress through primary school and eventually graduate into secondary school where they face different areas of science at a relatively higher level. If they are to have a sound foundation in scientific processes, they must acquire the science process skills of observing, manipulating, recording, analyzing, interpreting, hypothesizing and reporting. This will help the pupils to take up science subjects and courses in future thereby preparing them to participate actively in the world of science which propels technological development of any nation.

Umoren (1998) states that "statistics of students' enrolment in science, technology and mathematics (STM) subjects in secondary and tertiary levels indicate that students…do not perform well in the subject." The low enrolment at these levels shows that academic achievement at the primary school level is equally poor. Pupils' low academic performance in both internal and external examinations have been a matter of concern for parents, teachers, administrators and the society as a whole. This may be due to lack of understanding of scientific concepts or the difficult nature of the concepts at this level of education [2].

A concept is termed difficult when there is lack of understanding of such a concept by school pupils which could lead to low academic performance in science. According to Boyes and Staristreet (1990) one of the limitations to understanding scientific concepts arises from the misconception which lies in the interchangeability of vocabulary between the scientific language and everyday domains which the children experience [3]. In the same vein, Okebukola (2002) maintained that a barrier to understanding scientific concepts lies in the distance between the language of science and the mother tongue [4]. The author further said that science involves logical chains of argument coach in abstract language which can hinder pupils' understanding of scientific concepts. The terminologies used in science are quite strange to pupils who may find difficulty in learning these terms because some terms in science are of foreign origin and most at times may mean two different things in the children's local language. It is this conflict that creates misconception of science concepts for pupils which later cause poor academic performance of pupils in the subject.

The knowledge pupils acquire before entering into the classroom is of utmost importance on how pupils learn in school most especially science. Environmental experiences of pupils help them in the study and understanding of scientific concepts in school thereby enhancing their academic performance. Science generally deals with phenomena in the children's environment and when what is taught in school does not reflect the daily experiences, difficulty will set in, in the understanding of the concepts involved.

2. LITERATURE REVIEW

Scientific language and its use in the teacher-students classroom interaction is another area of interest in the learning and studying of science in school. Igwebuike (1991) in a research study has highlighted the problem of mother-tongue interference in the development of scientific concepts in pupils [5]. The author maintained that some scientific terms have different meanings from what the pupils imagined in the mother-tongue which normally give rise to misconception of such concepts by pupils. Umoren (1998) opined that, there are some words in science that have corresponding mother-tongue expression and also that some science concepts have more than dual meaning [2]. The confusion created by this is what leads to pupils' misconception of the concepts.

Also, Nwosu (1999) affirmed that, there is difficulty in meaning of concepts from one language to another [6]. This difficulty is variously experienced by pupils in the course of learning science concepts in school. More so, Umoren (1998) indicated that most concepts in science are either Greek or Latin origin [2]. These languages are foreign and alien to the Nigerian child who neither understand nor speak the languages. Okebukola (2002) posited that, vernacular misconceptions arise from the use of words that mean one thing in everyday life and another in science context [4]. Research efforts indicated that verbal communication is a very powerful tool in an effort to communicate science to learners. In communicating science to students, if the language used is not clear, the student will find difficulty in understanding what is being taught, also when higher order concepts are communicated to students without considering the lower order concepts which are pre-requisites to the higher order concepts, the students will not understand the concepts [7].

According to Ivowi (1991), the language of science has no touch of honor, no eloquence in its composition, no warmth of human emotions, and no grace of literacy decoration and because of its clarity, precision and constancy; it is a cold, plain and forthright language [8].

Nwosu (1998) pointed out that, the major problem faced by Nigerian students is the understanding of the language of science, part of which is caused by the deficiencies of science teachers [6]. In reference to

teacher factor, when teachers who teach the students find difficulty in understanding scientific language, the students would likewise experience similar difficulty. Piwuna (1998) carried out an empirical study on language problems of some science students-teachers [9]. The study revealed that, 88.3% of the students-teachers had one language problem or the other when delivering the subject matter. The author pointed out that, with 33.75 hours contact period 1.638 errors were made. Averagely, each student- teacher made about 36 errors within 45 minutes. In reference to the study, it is clear that misconception by teachers due to language inability is a determining factor in students' misconception. Soyibo (1982) maintained that, linguistic difficulties have a significant effect on pupils' ability to think [10]. From the author's position, if pupils have difficulties in scientific language, they would not be able to study science since science is naturally thought provoking.

Several researches have drawn scholars' attention to the interference of mother-tongue in the development and learning of scientific concepts and its effects on pupils' academic performance. Igwebuike (1991) affirmed that, the Ibos for instance have the same word for an animal and meat 'anu' which probably may bring misconception in the study of such concepts in science [5]. Similarly, Bette people have the same word for fish and wood, 'ukuan' which for sure will bring misconception in the study of such concepts among the pupils of that area. Also Adeniyi (1985) identified some misconceptions among Yoruba students in ecology. These misconception was traced to previous conceptions and misconception related to pressure, photosynthesis and respiration whose equivalent were absent in Yoruba language. Bolorunduro and Onaolapo (1994) carried out a research on pointers to difficult concepts in STM subjects [11]. The result revealed that, complexity of terms in science is one of the pointers. According to the authors one comes across a lot of technical terms in STM subjects in which in some cases these terms have different meaning in everyday use of the language hence there is misconception arising from inter-changeability of vocabulary.

Furthermore, Umoren (1998) is of the view that, one of the reasons for this linguistic difficulties pupils experience in understanding scientific concepts is the linguistic competence of the teacher [2]. The author maintained that, besides the inability of the teachers to communicate these concepts is the difficulty some teachers have in expressing themselves when using the technical terms involved in science. It is therefore important that teachers should have the grasp of the scientific language or vocabulary to enable them communicate these technical terms adequately to students. Ben-zvi & Hofstein (1996) affirmed that one of the factors that contribute to learning difficulties by students in science is communication problems arising from language use, general terms with context-specific specialized meanings, and the complexity of the sentence structure and syntax used by teachers, compared with the students own language [12].

From the foregoing, it can be inferred that language plays a significant role in the understanding and development of science concepts by pupils. Therefore, to help clear the misconception due to language, teachers had to acquire the language first to enable them teach science effectively. Pupils' pre-experience or pre-requisite knowledge of scientific concepts is an area of concern for science educators for the development and learning of science concepts. It is a well known fact that primary school level forms the basis for other educational levels. Therefore, the development and learning of scientific concepts has to be grounded at the foundation level to boast the study of science at other levels of education. Umoren (1998) pointed out that deficiency in pre-requisites knowledge by pupils in science is one of the problems the primary school teacher has to contend with hence it facilitates the comprehension of science concepts [2]. Similarly, Head (1985) claimed that individual's prior conceptions are derived from experience within the environment and their existing ideas, which are used to model new situations [13].

Ben-zvi & Hofstein (1996) carried out a study on student's learning difficulties in introductory chemistry. A survey design was used for the study. The sample was made up of 337 students from 11 tenth-grade classes. The students studied chemistry for a period of eight months. The instrument for data collection was a chemistry test and questionnaire. Data was analysed using independent t-test. The result revealed among other things that learning difficulties in chemistry are caused by deficiencies/inadequacies in students' knowledge structure. Based on the findings, student's knowledge structure and prior experience play a significant role in the study of science concepts by students.

The conceptual change literature suggests that the transition to a more formal conception will be successful only if recognition of the variability of the individual's initial conceptions is made. In the same vein, Enukoha (1998) affirms that, to understand a particular concept in mathematics, one must understand the lower order or pre-requisite concepts to it [7]. The author maintains that, two types of concepts exist, which are primary and secondary concepts. The understanding of the secondary concepts according to the author is therefore dependent on the primary concepts which are derived from our sensory and motor experiences.

Gagne (1977) in Ibe (2000) stated that, any knowledge can be acquired by pupils who possess certain pre-requisite pieces of knowledge which have their pre-requisites in turn. Gagne went further to stress that abstract principles and complex problem-solving skills are acquired with greater facility when more simple and concrete antecedents are acquired first [14]. Based on this assertion, it is inferred that, pupils can learn difficult

concepts easily when they possess the pre-requisite knowledge of the concepts. Similarly, Ausubel (1968) in Okebukola (2002) asserted that, meaningful learning involves relating new ideas and facts in some sensible manner to already existing established ideas and concepts in the learner's cognitive structure. In an attempt to explain Bruner's theory of instruction, Ibe (2000) opined that, the theory entails that learners interpret a learning experience or task essentially in terms of its similarities to and differences from what the learner already know hence Bruner asserts that any subject can be taught effectively in some intellectually honest way to any child at any stage of development.

Asim (2002) observed that crucial factors identified by researchers in the last two decades are children's preconceptions and misconceptions in science [15]. Such conceptions according to the author brought to the classroom environment determine to a large extent the type of learning that takes place. Furthermore, the author stressed that since misconceptions interfere with learning, if not corrected, new knowledge should be related to what the children already know.

Wright (1995) is of the view that the understanding of mathematical and scientific concepts is dependent on two factors that are closely related-experience at the concrete, semi concrete and abstract level and the child's stage of cognitive development [16]. The author therefore concluded that, it takes time and a sequence of experiences from concrete to abstract in order to build mental images in the mind of the child who is cognitively ready.

Asim (2002) carried out an empirical study on profile of children's misconceptions in air pressure, heat and electricity. The sample consisted of 164 primary 5 pupils. The instrument for data collection was a 28-item, 4-option multiple choice test and still 15 of the pupils were further interviewed. In terms of air pressure, it was revealed that the children were unable to grasp the effect of still air, while an empty coke bottle was said to contain nothing not even air. Even when the investigator made the children to understand that air exist everywhere, some children still use irrelevant features to explain why air was not in the bottle. The author therefore states that, the observation was not out of place because many researchers have found that children construct meaning from experience. Based on this, it can be inferred that without prior experience, pupils would find it difficult to construct meaning of any concept presented to them. Thus, what they have not experienced according to Asim (2002), they find difficult to understand. In order to develop a more effective teaching strategy to overcome students' misconception in science, Mansfield and Happs (1996) consider such factors as the central ideas that students bring with them to the learning situation [17]. However, to avoid misconception and enhance understanding, Ausubel (1963) in Maduabum (1994) advocated for advance organizers [18]. The advance organizers could be in form of a probe or the learning materials that are relevant to the learning of new knowledge to be presented.

Lindgren (1979) opined that, skills and information are best learned and best retained when they are organized into conceptual systems [19]. These systems according to the author are usually directly related to children's immediate experiences. Such experiences can involve a great range of cognitive skills and lead to accumulation of much information which in themselves serve as basis for organizing the information into concepts.

Gagne (1970) in Lindgren (1979) carried out a research in elementary school mathematics titled "Learning and proficiency in mathematics" [19]. The predictions made by mathematicians, experimental psychologists and mathematics teachers in the experimental studies show that an individual will not be able to learn a particular topic if he has failed to achieve any of the subordinate topics that supports it. The author reported their experimental result thus: "our result implies that there are many specific sets of readiness to learn, if these are present, learning is at least highly profitable; If they are absent, learning is impossible". Again, Ausubel in Okebukola (2002) commented on the importance of preconceptions in the process of learning, noting that, they are "amazingly tenacious and resistant to extinction… the unlearning of preconceptions might well prove to be the most determinative single factor in the acquisition and retentions of subject-matter knowledge" [4].

From the foregoing it can be deduced that preconceptions arise as a result of non existence of pre-requisites or subordinates rules which aid in learning and understanding of scientific concepts.

3. PURPOSE OF THE STUDY

The major purpose of this study is to determine the extent to which limitations to understanding scientific concepts relate to pupils academic performance in primary science. Specifically the study seeks to examine the extent to which:

1. Scientific language relates to pupils academic performance in primary science
2. Pupils pre-experience of science concepts relates to their academic performance in primary science.

4. RESEARCH QUESTIONS

In order to carry out the investigation on this issue, the following research questions are formulated to guide the direction of the study:

1. How does pupils' perception of scientific language relate to their academic performance in primary science?
2. To what extent does pupils' pre-experience of scientific concepts influence their academic performance in primary science?

5. HYPOTHESES

In an attempt to answer the above research questions, the following hypotheses are formulated to guide the study.

1. There is no significant relationship between pupils' perception of scientific language and their academic performance in primary science
2. Pupils' pre-experiences of scientific concepts do not significantly relate to their academic performance in primary science.

6. RESEARCH METHOD.

The study adopted the Expost-facto research design. The population of the study consisted of all the 2005/2006 academic session of primary six pupils in the three Education zones of Cross River State. The total was 68,201 pupils with 34396 males and 33805 females. A proportionate stratified sampling technique was used to select 70 schools out of 994 to participate in the study. A simple random sampling technique of hat and draw method was further used to select 1,818 pupils who participated in the study. Two instruments were used for data collection via- limitations to understanding scientific concepts questionnaire(LUSCQ) and a 50 item primary science achievement test were administered after which data was coded for analysis. The instruments were face validated as well as content wise. The reliability was carried out using Cronbach Coefficient alpha method. The estimates ranged from 0.50-0.90 which were considered appropriate.

7. RESULTS

HYPOTHESIS 1

This hypothesis postulated that there is no significant relationship between pupils' perception of scientific language and their academic performance in primary science. Pearson Product Moment Correlation Coefficient (r) analysis was used to test the hypothesis. The result is presented in Table 1.

Table 1. Pearson product moment correlation coefficient (r) analysis of the relationship between pupils' perception of scientific language and academic performance in primary science

Variable		Σx	Σx^2	xy	r-value
		Σy	Σy^2		
Scientific language (X)	818	8073	19107	678569	.4139*
Academic performance(y)	7	7011	425496		

P < .05; df = 1816; critical r-value = 0.1946

From Table 1, the result indicated that the Pearson Correlation (r) analysis is 0.4139, which is greater than the critical r-value of 0.1946 at .05 level of significance with 1816 degrees of freedom. Going by the result, the null hypothesis of no significant relationship was rejected while the alternate hypothesis is upheld. This means that there is a significant relationship between pupils' perception of scientific language and their academic performance in primary science. This implies that if pupils have clear understanding of the technical terms used in science, they will be able to study science and their academic performance will be enhanced.

HYPOTHESIS 2

This hypothesis postulated that there is no significant relationship between pupils' pre-experience of scientific concepts and their academic performance in primary science.

Pearson Product Moment Correlation Coefficient (r) analysis was used to test the hypothesis. The result is presented in Table 19.

Table 2. Pearson product moment correlation co-efficient (r) analysis of the relationship between pupils' pre-experience of scientific concepts and their academic performance in primary science.

Variable	Σx	Σx^2		xy	-value
	Σy	Σy^2			
Pre-experience (X)			5		
	7478	0611			
	818			197155	.2725*
Academic performance (y)			3		
	7011	425496			

P < .05; df = 1816; critical r-value = 0.1946

From Table 2, Pearson product Moment Correlation Coefficient (r) value of 0.2725 was obtained. This was observed to be greater than the critical r-value of 0.1946 at .05 level of significance with 1816 degrees of freedom. The higher calculated r-value of 0.2725 indicated that there is a significant relationship between pupils' pre-experience of scientific concepts and their academic performance in primary science. Hence, the null hypothesis was rejected. The implication of this is that if pupils acquired enough experience of scientific concepts as they interact with their environment, they stand a better chance of studying science even in the higher levels.

8. DISCUSSION

From hypothesis 1, the null hypothesis was rejected based on the finding that there is a significant relationship between pupils' perception of scientific language and their academic performance in primary science. This implies that pupils' perception of scientific language is significantly related to their academic performance in the subject. In other words, if pupils do not understand the language of science, in terms of the technicality of the science language, it will affect their performance in science.

This finding is consistent with the view of Nwosu (1998), who opined that the major problem faced by Nigerian students is the understanding of the language of science. This is because science has its own language and for anyone to study science, the person must understand the language of science [6]. Also, Igwebuike (1991) in a research study highlighted the problem of mother-tongue interference in the development of scientific concepts [5]. The author maintained that some scientific terms have different meanings from what the pupils imagined in the mother-tongue. This means if there is conflict between the technical terms in science and what the pupils assume in their mother-tongue, they may be unable to understand science concept which goes to affect them academically.

Furthermore, Okebukola (2002) agreed that vernacular misconceptions arise from the use of words that mean one thing in everyday life and another in science context. The probable reason could be that if the science terms are difficult to understand coupled with the interference of mother-tongue, the pupils will not find science easy to study and this will affect their academic performance in the subject [4].

This finding is in consonance with the research finding of Soyibo (1982) who maintained that linguistic difficulties have a significant effect on pupils' ability to think. This of course will be evident in the pupils' performance in science, which is thought-provoking [10]. Again, Bolorunduro and Onaolapo (1994) in a study reported that pointers to the difficult concepts in STM subjects are as a result of the complexity of terms in science [11].

Accordingly, Ben-zvi and Hofstein (1996) affirmed that one of the factors that contribute to learning difficulties by students in science is communication problems arising from language use, general terms with context-specific, specialized meanings and the complexity of words used in science [12]. The implication of these consistencies is that if the technical terms in science are not understood by pupils coupled with the fact that the words may mean one or two things in the pupils' mother tongue, pupils will find it difficult to study science which invariably will affect their academic performance in science.

From hypothesis 2, the null hypothesis was rejected because the finding from the analysis showed that there is a significant relationship between pupils pre-experience and their academic performance in primary science. This implies that when pupils have pre-requisite knowledge of the scientific concepts before these concepts are presented to them in the classroom, they will understand the concepts better and their academic performance in science will be enhanced.

This finding is consistent with the view of Gagne (1977) in Ibe (2000), who maintained that any knowledge can be acquired by pupils who possess certain pre-requisite pieces of knowledge which have their pre-requisite in turn [14]. That is if pupils acquire pre-requisite knowledge of scientific concepts, they will understand the subsequent ones when presented to them in the classroom.

Also the finding of this study agrees with Ausubel (1968) in Okebukola (2002) who found that meaningful learning involves relating new ideas and facts in some sensiblse manner to already existing established ideas and concepts in the learners cognitive structure [4]. That is if pupils must understand science concepts they must have some science ideas and concepts existing in their cognitive structure.

This study is in support of the opinion of Enukoha (1995) who asserted that to understand a particular concept in mathematics; one must understand the lower order or pre-requisite concepts to it [7]. Probably, if science concepts are presented to pupils considering the lower order concepts, science may be made more easier for pupils to study.

The finding is also supportive of Asim (2002) in a study on profile of children's misconception in air pressure, heat and electricity that the observation of children's misconception about the absence of air in an empty bottle was not out of place because many researchers have found that children construct meaning from experience [15]. The author therefore stressed that, what they have not experienced, they find difficult to understand. Based on these findings, the researcher is of the view that for the primary school pupils to learn and understand scientific concepts adequately, new lessons must be linked to the existing experiences which the children have acquired as they interact with their environment.

9. CONCLUSION

It was concluded that scientific language and pupils' pre-experience of scientific concepts have significant relationship with pupils' academic performance in primary science. This implies that, if pupils have clear understanding of the technical terms used in science and having enough experience of science concepts, they will study, learn and internalize the concepts. This will help them to have better understanding of the concepts which will enhance their academic performance in primary science.

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