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ABSTRACT

This study was designed to examine the amount of incidental physical science knowledge possessed by fourth-, fifth-, and sixth-grade students in elementary schools in Western State of Nigeria, and to determine what relationship exists between the amount of such knowledge and the pupils' performance on science-related Piagetian tasks. The pupils were tested with the Physical Science Knowledge Test and numerous Piagetian tasks. The responses of the pupils were then subjected to an iten-by-item analysis and to the t-test, analysis of variance, and correlational analysis. Some of the results of this study were: there was a significant difference between the amount of incidental science knowledge possessed by urban school children and that possessed by their non-urban counterparts; the performances on the Piagetian tasks were age-dependent, with the older children performing better than the younger children; and a significant positive correlation was found between the amount of incidental science knowledge possessed by school children of each grade of study and their performance on the Piagetian tasks. (Author/MLH)

Sponsoring Committee: Professor Herbert Schwartz, Chairman
Professor Michael Adragna
Professor Frances Minor

A STUDY OF THE NATURE OF INCIDENTAL PHYSICAL SCIENCE KNOWLEDGE POSSESSED BY ELEMENTARY SCHOOL CHILDREN IN WESTERN STATE OF NIGERIA

ADEDIRAN A. TAIWO

Submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in the School of Education of New York University

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ABSTRACT

Synopsis

This study was designed and executed to examine the nature and the amount of incidental physical science knowledge possessed by fourth, fifth and sixth graders in elementary schools in Western State of Nigeria; and to determine whatever relationship that might exist between the amount of such knowledge and the pupils' performance on science-related Piaget-like tasks.

Introduction

As the government of Western State of Nigeria is on the threshold of introducing comprehensive elementary science into all elementary schools in the State in the foresecable future and as many school children in the State still come to school from homes which can be described as "superstitious," there is need to ascertain the incidental science knowledge and misconceptions about science possessed by elementary school children in the State. In this respect, the curricular implications of the incidental science knowledge and misconceptions possessed by school children in the State cannot be overestimated.

Methodology

The two instruments (one named Physical Science Knowledge Test and the other Interview Guide for Piaget-like Tasks) used in this study

were constructed by the investigator after giving careful consideration to both cognitive and cultural milieus of the population. The construction of the instruments was followed by validation exercise which comprised, among other things, the use of committees of experts and item analysis. And the reliabilities of the instruments were found to be 0.616 and 0.692 respectively from the statistical analyses involving the application of the split-half method and Spearman-Brown Formula on the performances of 120 subjects. The instruments were later administered, for the purposes of collecting data for this study, to a total of 979 subjects in grades four through six of twelve randomly selected schools in the State.

The responses of the subjects were then subjected to an item-by-item analysis, and to both inferential and non-inferential statistical analyses which included t-test, analysis of variance and correlational analysis.

Results and Conclusions

Within the realm of the design of this study, a number of results and conclusions appear justified. Some of these are:

1. There appears to be widespread unscientific beliefs concerning rain and rainbow among the subjects of this study.

2. The subjects could be said to possess a better-than-chance knowledge of incidental science knowledge.

3. There is a significant difference between the amount of incidental science knowledge possessed by urban school children and that possessed by their non-urban counterparts.

4. The performances of the children on the Piaget-like tasks appear, to a large extent, to be age-dependent with older children performing better than the younger children.

5. A significant positive correlation exists between the amount of incidental science knowledge possessed by school children of each grade of study and their performance on the Piaget-like tasks.

Implications

Deriving from the findings of this study, a number of implications for science education in the State appear justified.

1. There is need to help children in the State to allay the fears of the unknown and do away with unscientific beliefs which could constitute an impediment in their learning of science.

2. Efforts should be made by the State government to provide stimulating environment for the rural child so as to assist him to stand in good stead with his urban brother.

3. The findings of this study also have implications for content selection and grade placement since it was found that children in classes four to six of elementary schools in Western State of Nigeria are within the level of development termed "concrete level" by Piaget.

ACKNOWLEDGEMENTS

Had it not been for the generous assistance and co-operation of a number of people and institutions, this study would not have materialized. And while it would be almost an insurmountable task to name all the individuals who made this study possible, let alone acknowledging their contributions, the investigator would like to acknowledge helpful assistance received from the following people and institutions for their singular and invaluable contribution to this study.

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And in fact, their suggestions, criticisms, comments and observations had helped a great deal in shaping this study. Their role in this study is far greater than words can describe. My unqualified thanks go to them both.

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Dedicated to the cherished memory of

OLASENI TAIWO

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CHAPTER I

INTRODUCTION

This chapter discusses, among other things, an overview of the status of elementary science education and the current science education thinking in Western State of Nigeria.

1.1 An Overview of the Status of Elementary Science Education in Western State of Nigeria: Past, Present and Future.

As a preamble to this study, some aspects of Nigerian education which are pertinent to this study are presented in the following paragraphs.

Western State of Nigeria, which is one of the twelve states that make up the Federal Republic Nigeria can boast of over 3,845 elementary schools[1] and a pupils' population[2] of over 869,765 today. Elementary education in the public schools of the State is free but not compulsory.[3] At the present moment, children are admitted into

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[1, 2] Gleaned from: A Summary of Current Education Statistics, published in October, 1971 by the Statistics Division of the Ministry of Economic Planning and Reconstruction, Ibadan, pp. 3-5.

[3] The Federal Government of Nigeria has already set up machinery to make elementary education both free and compulsory throughout the length and breadth of the Federation of Nigeria as from September, 1976.

elementary schools in the State at about the age of six; and during the six years they are expected to spend in elementary schools, they are exposed to subjects such as Yoruba Language, English Language, Geography, Arithmetic, Gardening, Nature Study, Hygiene and other subjects. However, what constitutes science education in most of the public elementary schools in the State at present are the so-called "science-related" subjects, viz. Gardening, Nature Study and Hygiene which consist of only selected and restricted aspects of biological sciences as revealed by their contents.[4]

The present status of science education in elementary schools in the State could be summed up in the following words of Aderinlewo[5] of the State's Ministry of Education:

> With the exception of a few schools where some experimental science programmes are being tried on a pilot basis, most schools dc not teach anything one could label as formal science (in the sense of basic, or general science, or biology, or chemistry, or physics, etc.). The only subjects that bear any close resemblance to formal science, at least in terms of subject matter content, are Nature Study, Gardening and Health Science (or Hygiene).[6]

He went further to lambast the contents of the "science-related" subjects as "a miscellany of topics without any unifying concepts or

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[4]See Appendix VII for the contents of the so-called "science-related" subjects.

[5]Ezekiel Aderinlewo, "Introducing a New Method of Teaching Elementary Science in the Western State of Nigeria," (Unpublished Essay, 1971).

[6]*Ibid.*, p. 6.

or themes."[7] This limited and poorly organized science education set-up in the elementary schools of the State is part of the State's colonial heritage from the British; but the picture has not changed since Nigeria's independence some fourteen years ago due to problems ranging from lack of finance to lack of adequately qualified science teachers and science facilities.

A direct consequence of the above fact is that any knowledge which the generality of pupils in public elementary schools in the State might possess concerning concepts about electricity, magnetism, light, sound, heat, mechanics and other physical phenomena must have been acquired incidentally in the sense that such knowledges must have occurred through non-instructional, informal means such as the pupils' personal observations and/or their interactions with their peers, their parents and even their teachers during informal discussions.

It should not, however, be construed that the State authorities had not been and are not thinking seriously and sympathetically about ways and means of enriching the child's school experience through a broad-based elementary science education encompassing all the different facets and dimensions of science. Far from it. In fact, there is a growing feeling both within the governmental body responsible for education, that is, the State's Ministry of Education and among educators that

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[7] Ibid., p. 7.

science education in elementary schools in the State should be more comprehensive than it is at present. The reason for this feeling is not far-fetched. It is now a common belief in Nigeria, as in most developing nations of the world, that education is a key factor in "revolutionizing" both the living conditions and the standard of living of the country's teeming population. And, as a matter of national urgency, Nigeria should be able to tackle successfully, in the very near future, problems concerning the "development of adequate transport [facilities] ..., water supply, soil erosion, health and sanitation, modern scientific farming"[8] and a myriad of other problems if she is to enjoy any respectability among the nations of the world. In addition to this, Nigerian citizens should have basic training in science so as to be able to allay the fear of the unknown as the generality of Nigerian citizens still believe that:

> Thunder and lightning, echoes and rain, the sun, the stars and the moon, the rivers and the land, the trees and the forests have supernatural powers which could be invoked if the accredited village medicine man would pour the necessary libations....[9]

Needless to say that all the problems enumerated above require a scientifically conscious population for their solutions. But the problems

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[8] A. Babs Fafunwa, New Perspectives in African Education, (Lagos: Macmillan & Co. (Nigeria), Ltd., 1967), p. 8.

[9] Ibid., p. 14.

are further complicated by the fact that the bulk of the citizens of Western State of Nigeria are not likely to have more than elementary education for some time to come.[10] Consequently, there is an urgent need to place considerable emphasis on science education at the elementary school in the State. A more radical view on this subject was presented by Fafunwa:

> It is a sine qua non, therefore, that this new generation of citizens should have more scientific background at [the] elementary level of education than the Western [European] counterpart at the same level.[11]

It is pleasing, however, to learn that some steps are being taken in the right direction. For example, a number of bodies in the State have already suggested to the State's authorities some ways and means of revamping science education in elementary schools to reflect current modern thinking in science education. In the recent times, two different commissions[12, 13] instituted by the government, did not only recommend the introduction of modern science teaching into the elementary school curriculum but also prescribed that a modern and a more

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[10] This is because less than ten percent of elementary school graduates proceed to have high school education chiefly because high school education is not free in the State.

[11] Op. cit., Fafunwa, pp. 8-9.

[12] Government of Western Nigeria, Banjo Commission Report, (Ibadan: Government Printer, 1961).

[13] Western State of Nigeria, Taiwo Committee Report, (Ibadan: Government Printer, 1968).

enriching science curriculum, as opposed to the "old stuff" of fact-ridden and restricted "science-related" subjects, should be developed by a committee of scientists and science educators.

And the burning desire for action has, in fact, already triggered off in recent times at least two major curriculum development projects by the State's Ministry of Education. The first of these efforts culminated in the official adoption of an elementary school science syllabus for primary classes V and VI in 1968. A government's paper[14] on this subject reads thus:

> Prior to 1965, the current elementary School Syllabus has Nature Study/Gardening/Health as a composite subject. The first draft of the present Elementary Science Syllabus compiled for Primary Classes V and VI only came into being in 1965. This was experimented with in seven schools in Ibadan Township in 1965/66. ... In 1968, the final draft of the primary School Science Syllabus, Western State was approved....

Although a lot of planning about the execution of the Syllabus was undertaken before its official approval in 1968, the project never got off the ground before it was abandoned due to problems ranging from lack of science facilities and materials to lack of qualified teachers to implement the project in schools. In addition to the above fact, it was discovered that it would take a "super-pupil" to surmount the big science knowledge "gulf" between primary class IV science syllabus and primary class V science syllabus, in that the new science

14 See Appendix XII.

syllabus (for classes V and VI only) was found to be out of gear with the kind and scope of science knowledge the pupil should have been exposed to in Classes I to IV. But these are not all the problems that beset the project. It, in addition, failed to gain the cooperation of the only public examination body in the country. This means that any school which upholds and teaches the new science syllabus to its pupils exposes them to a task that will not be rewarded diploma-wise.[15] However, this problem did not have to be resolved in the first place as there were no facilities in the public elementary schools for the new project.

Having learned from past experience, the State's Ministry of Education made another attempt at a science curriculum development project for elementary schools in 1972. A new syllabus, a more comprehensive one, was designed for primary classes I through VI by a committee consisting of Ministry officials, science educators and experienced elementary school teachers. The product of the deliberations of the committee, the new syllabus, was then reviewed later that year by a critique conference comprising selected Ministry officials and science educators. The new syllabus was then officially adopted by the

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15 It is significant to note that the educational system in both elementary and high schools in Nigeria is still plagued with a centralized examination system inherited from the former colonial masters, the British.

State's Ministry of Education, after some minor modification and ratification by the critique conference. A curriculum committee,[16] consisting of Ministry officials, science educators and experienced practising elementary school teachers, was then charged with the task of writing a Teacher's Guide for the new syllabus. It should be stated in passing that each portion of the Teacher's Guide, like the draft of the syllabus, has to be ratified by a critique conference for its suitability and relevance to the child in particular and to the society in general before its official approval and adoption. Up to the time of writing, both the curriculum committee and the critique conference had completed work only on the primary Class I portion of the Teacher's Guide. This portion of the Teacher's Guide which is now an official paper is to be introduced soon to selected elementary schools in the State on an experimental basis; and for the successful implementation of this portion of the project, the State's Ministry of Education intends to give Induction Courses to participating teachers about the new syllabus and the primary Class I portion of the Guide before introducing them to the selected schools. In addition, the Ministry intends to set up, before long, a

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[16] Incidentally, the investigator was an active committee member for 1973/74 session during which time he was in Nigeria collecting data for this study (see Appendix XIV).

machinery for gathering feedback from participating schools for evaluation purposes. Other portions of the Teacher's Guide (for Primary Classes II to VI), when approved, will be introduced to the selected schools in the same manner as the primary class I portion of the Guide, year after year. The project will be experimented with in the selected schools for a total of six years.

In preparation for the day the project will be implemented in all schools following satisfactory evaluation results, the State's Ministry of Education has started training elementary school teachers and equipping selected schools with science apparatus. For, according to a Ministry's report:[17]

> The number of [science] teachers trained has systematically grown from 28 in 1967 to 524 by March 1973. ... Equipment to the tune of N8, 000 (about $12, 000) has already been supplied in 1972/73 to the zonal centres. Equipment to the tune of N18, 000 (about $27, 000) has also been ordered... in 1972/73.

Tables 1 and 2 below give the statistics connected with the training o. elementary school science teachers in the State by zonal centres and/or dates.

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17 See Appendix XIII.

TABLE 1

PRIMARY SCHOOL SCIENCE TEACHERS: (WESTERN STATE)

NUMBER ALREADY TRAINED UP TO DECEMBER 1972

	ZONES	CENTRES		ALREADY TRAINED UP TO					TOTAL
				1967	1968	1969	1970	1971	1972	
1.	Ibadan/Oyo	i.	Ibadan	28	40	28	16	5	2	119
		ii.	Oyo	-	-	-	18	20	24	62
		iii.	Ibarapa	-	-	-	36	2	-	38
			Total	28	40	28	70	27	26	219
2.	Ijebu/Egba	i.	Ijebu-Ode	-	-	-	-	-	24	24
		ii.	Sagamu	-	-	-	-	-	17	17
		iii.	Abeokuta	-	-	-	-	-	34	34
		iv.	Ilaro	-	-	-	-	-	-	-
			Total	-	-	-	-	-	75	75
3.	Osun/Ife Ijesha	i.	Osogbo	-	-	-	34	33	35	102
		ii.	Ejigbo	-	-	-	-	21	-	21
		iii.	Ife	-	-	-	-	-	53	53
		iv.	Ilesha	-	-	-	-	-	26	26
			Total	-	-	-	34	54	114	202
4.	Ondo	i.	Akure	-	-	-	-	28	-	28
		ii.	Ondo	-	-	-	-	-	-	-
			Total	-	-	-	-	28	-	28
			GRAND TOTAL	28	40	28	104	109	215	524

TABLE 2

TOTAL NUMBER OF SCIENCE TEACHERS TRAINED

OVER THE YEARS: 1967-1972

1967	1968	1969	1970	1971	1972
28	68	96	200	309	524

By March 1973, a total of 293 elementary schools[18] in the State had been supplied with some science apparatus according to the statistics below.

TABLE 3

WESTERN STATE - NIGERIA

PRIMARY SCHOOLS SCIENCE EQUIPMENT ALLOCATION

ZONES	NUMBER OF SCHOOLS
Ibadan/Oyo	97
Ijebu/Egba	35
Osun/Ife/Ijesha	144
Ondo	17
TOTAL	293

[18] See Appendix XII for the list of qualified schools.

All things being equal, the State's Ministry of Education plans to launch the new syllabus and its complete Teacher's Guide in all elementary schools in the State after the six-year experimental period. It is needless to say that it is the tacit wish of the protagonists of the new project that it will provide enriching and worthwhile experiences for school children in the State when it is formally adopted state-wide.

However, it would be presumptuous of the curriculum developers to assume that when the curriculum now in progress is finally introduced to all schools in the State in about 1980, it would be addressing itself to children whose minds are "tabula rasa." The new curriculum's success would, no doubt, depend on a number of factors among which is the science concepts and misconceptions about science possessed incidentally by the elementary school child in the State. So, there is need to ascertain the incidental science knowledge and misconceptions possessed by the child due to his personal observations and conjectures, his interactions with his peers as well as other members of his community and his exposure to books and media.

1.2 Statement of the Problem

The problem of this study is twofold:

i) to examine the nature and the amount of incidental physical science knowledge possessed by fourth, fifth and sixth graders in elementary schools in Western State of Nigeria, and

ii) to determine the relationship between the amount of such knowledge and the children's performance on Piaget-like tasks.

1.3 Sub-problems

1. To determine whether elementary school children in Western State of Nigeria possess a better-than-chance[19] knowledge of incidental physical science knowledge.

2. To determine whether elementary school children in the fourth, fifth and sixth grades in Western State of Nigeria differ in the nature and the amounts of incidental physical science knowledge they possess from grade to grade.

3. To determine whether elementary school children in urban areas of Western State of Nigeria differ from their non-urban

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[19] See definition of terms.

counterparts in the nature and amount of incidental physical science knowledge they possess.

4. To determine whether elementary school children in the fourth, fifth and sixth grades in Western State of Nigeria differ in their performances on Piaget-like tasks.

5. To determine whether elementary school children in urban areas of Western State of Nigeria differ from their non-urban counterparts in their performance on Piaget-like tasks.

6. To determine whatever relationship might exist between the amount of incidental physical science knowledge possessed by school children of each grade of study and their performance on Piaget-like tasks.

1.4 Hypotheses

Deriving directly from the sub-problems of this study are the following hypotheses:

1. It is hypothesized that elementary school children in Western State of Nigeria possess a better-than-chance knowledge of incidental physical science knowledge.

2. It is hypothesized that there are differences in the nature and the amounts of incidental physical science knowledge possessed by the fourth, fifth, and sixth graders in Western State of Nigeria.

3. It is hypothesized that there are differences in the nature and the amounts of incidental physical science knowledge possessed by

school children in the urban and non-urban areas of Western State of Nigeria.

4. It is hypothesized that there is a difference in the performances of school children in the urban and non-urban areas of Western State of Nigeria on Piaget-like tasks.

6. It is hypothesized that there is a positive correlation between the amount of incidental physical science knowledge possessed by school children of each grade of study and their performance on Piaget-like tasks.

1.5 Delimitations

1. This study was limited to a random sample of twelve elementary schools in the State.

2. The amount of incidental physical science knowledge possessed by a subject of this study corresponded to the score he obtained on a sixteen-item multiple choice instrument designed by the investigator.

3. The Piaget-like tasks of this study were limited only to science-related activities.

1.6 Theoretical Rationale for the Study

The following theoretical rationale is provided in order to place this study in a broader educational context. As a study dealing with incidental learning, the theoretical framework of this study centres around educational theories dealing with "spontaneous" and "non-spontaneous" learnings, the principle of readiness, and the relationship between culture and cognition.

The distinction between "spontaneous" learning and "non-spontaneous" learning stems from the difference in the modes by which the child acquires concepts. "Spontaneous" learning is the process through which the child's ideas are formed through his own mental efforts, while "non-spontaneous" learning is the means through which the child's concepts are developed through his interactions with the adult.[20] Vygotsky claimed that "the two processes— the development of spontaneous and of non-spontaneous concepts— are related and constantly influence each other."[21] This view is not only shared by the investigator of this study but also reinforces his idea about the role of "spontaneous" and "non-spontaneous" learnings in the realm of incidental learnings, in that the

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[20] L. S. Vygotsky, Thought and Language, (Mass.: The M. I. T. Press, 1962), p. 84.

[21] Ibid., p. 85.

two processes do play important roles in the nature and the kind of incidental learnings that might occur. In fact, this study has "spontaneous" learnings as well as "non-spontaneous" learnings as its focal point in the sense that any incidental science knowledge possessed by children must have been acquired through both "spontaneous" and "non-spontaneous" learnings.

Coupled with the theory of "spontaneous" and "non-spontaneous" learnings is Piaget's "four main factors"[22] which are necessary for learning. He identified these as maturation, experience, linguistic transmission and equilibration. It is the contention of this investigator that these factors are fundamental to the acquisition of concepts and knowledges incidentally. For how else could the child assimilate concepts dealing with physical and natural phenomena without the presence of the four factors in their "proper" proportions?

Another theoretical ingredient of this study, which is closely tied with the above, concerns the role of the principle of readiness in incidental learnings, or any learnings for that matter. For example, a one-year-old child cannot master how to read because he is not yet "ready," both physically and intellectually to perform that role. This means that certain developments have to take place before the child

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[22] Jean Piaget, "Development and Learning," in Piaget's Theory of the Development of Thought, edited by Murray, (New York: MSS Information Corporation, 1972), p. 59.

will be able to acquire certain skills, knowledges and understandings. An extension of this view was presented by Piaget in his theory of phases and stages of development.[23]

The last but not the least of the theoretical ingredients of this study focuses on the relationship between culture and cognitive development. Beliefs about natural and physical phenomena, such as rain formation, are derived from the way of life of a people in a given culture. And more often than not, these beliefs are interpreted as indications and reflections of the thought processes of the people of the culture concerned.

In the studies dealing with the relationship between culture as evidenced from beliefs and cognition as exemplified by thought contents and processes, three basically different schools of thought have emerged:[24]

> ...one school of thought maintains that salient differences in beliefs and category systems represent no more than differing conventions with little impact on thought processes; the opposing school holds that either a difference in beliefs or a difference in classification systems is sufficient evidence for differing thought processes. A completely different line of argument maintains that all evidence from group phenomena, such as beliefs and language categories

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[23] For further details, see the Review of Literature.

[24] Michael Cole, et. al., The Cultural Context of Learning, (New York: Basic Books, Inc., 1971).

> is irrelevant to understanding processes that are properties of individuals; only a study of the individual as a member of his group can lead to reliable information about culture and cognition.[25]

There is no doubt that the premises of each of the schools of thought have their strong and weak points; they all have something to offer. But while this study does not concern itself with a particular school of thought, it is important to note that a better understanding of the relationship between culture and cognition would result if aspects of ethnography are taken into consideration as well. This is to say that for adequate and proper interpretation of any result deriving from a study of this type, it is imperative that the ethos of the subjects should be thoroughly understood by the investigator. For it is then, that the real connection between data and interpretation could be made in relation to culture and cognition. In this respect, the ethnographic elements of the subjects of this study are brought to play in the design, execution and analysis of the data of this study.

1.7 Significance of the Study

This study is important for several theoretical and practical reasons. For example, the incidental physical science portion of this study is important for at least several reasons. First, the fact that

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25 *Ibid.*, p. 3.

no study of incidental science learnings among school children in Nigeria has, hitherto, been carried out makes this study important. As this is the first study of this kind in Nigeria, it might be anticipated that this study would open up new vistas of knowledge concerning incidental physical science learnings among elementary school children in Nigeria. This is important because of the curriculum implications which the findings of this study could furnish. This is borne out by the fact that Western State of Nigeria is on the threshold of introducing comprehensive elementary science into all her elementary schools in the foreseeable future. It might be anticipated, therefore, that the findings of this study would provide the science curriculum planner in the State with a clear picture of the areas of physical science that the child is "knowledgeable in" without the patronage of the formal school.

Another importance of this study could be derived from the views of a leading African educator concerning the "worlds" of the African child. According to this authority, the average African child comes from a family which "is superstitious and explains most natural phenomena and avoidable accidents as the will of God or of a supernatural being."[26]

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[26] A. Babs Fafunwa, New Perspective in African Education, (Lagos: Macmillan & Co. Ltd., 1967), p. 13.

Expatiating further on this subject, he said:

> Any child is fascinated with the world around him, the world above, and even the world below. To the African child and his parents, these are mysterious worlds, and both parents and child explain away the echoes, the rain, the stars, thunder and lightning either as the attributes of lesser gods, or the work of a bigger God, who controls their own activities. The rain falls, the thunder blasts, the lightning strikes a man or a woman when the creator wishes it. If lightning hits a universally acclaimed 'good man of the village,' it is generally believed that the 'good man' was not really good for he must have done something shameful, unknown to the general public. 'Lightning never hurts or kills a good man.' These supernatural gods, according to the villagers, can be bribed by libations or other concoctions offered by the village high priest— the medicine man or the witch doctor.[27]

From above quotations, it is abundantly clear that there is need to ascertain any science knowledge which might have been acquired incidentally by children growing up in Nigeria because such incidental learnings might consist of misconceptions of science concepts as well. And in case of widespread science misconceptions among elementary school children in Western State of Nigeria, the curricular implications for formal general science education in the State cannot be over-emphasized.

The Piaget-like tasks portion of this study is important for both theoretical and practical reasons as indicated below. It is hoped that this part of the study would open up new vistas of knowledge concerning the performance of Nigerian children on Piaget-like tasks in

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[27] Ibid., p. 22.

that the findings of this study might furnish useful information concerning the understanding school children in the age bracket of nine through eleven years in Western State of Nigeria might have about those tasks. In particular, this portion of the study might shed some light on the areas of Piaget's tasks in which Nigerian children in the age bracket of nine through eleven years have been able to reach what Piaget termed "concrete lev'l of operation." Coupled with Piaget's view on cognitive development is the need to determine whether there is a significant positive correlation between the children's performances on the Piaget-like tasks of this study and the amount of science knowledge they might have acquired incidentally.

The practical aspects of the importance of Piaget-like tasks portion of this study could be seen from two angles, viz., curriculum development (both content selection and grade placement) and teaching methods. Piaget postulated four major periods[28] in cognitive development from birth to adolescence. He further theorized that the stages are sequential and invariant although the "average age at which these stages appear (the average chronological ages) vary a great deal from one society to another."[29] This notwithstanding, Piagetian theories have grave implications for both curriculum development and teaching methods in that

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[28] For more details, see the section on "The Theories of Stages in Cognitive Development" in the next chapter.

[29] _Op. cit._, Jean Piaget, p. 59.

they do not only suggest appropriate activities for each stage of development (and consequently each school grade) but also what misconceptions and difficulties to expect in children. In the words of Beard:[30]

> To teachers it is of some importance not only to know the order of stages in thinking, if there is an invariable order, but also to know what misconceptions to expect among children of different ages and at what age the majority of children in a given environment reach each stage. Such information is valuable as a guide to teaching methods.[31]

And since the Piaget-like tasks of this study are science-related tasks, the findings of this part of the study might provide the science curriculum developer in the Western State of Nigeria with some useful information concerning the concepts and misconceptions of children in the State about some aspects of science. This would go a long way in the formulation of a viable science curriculum for elementary schools in the State in future; and it goes without saying that if the curriculum developer is armed with some information concerning the strengths and weaknesses of school children, he will be in a better position to suggest appropriate methods for teaching the different areas of the curriculum. This means that ultimately both the classroom teacher and the child in particular and the Nigerian society in general could benefit from the findings of this study.

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[30] Ruth Beard, An Outline of Piaget's Developmental Psychology for Students and Teachers, (New York: Basic Books, Inc., 1969).

[31] Ibid., pp. xx-xxi.

1.8 Definition of Terms

To avoid ambiguity in terminology, certain terms are defined for the purpose of this study as follows:

Incidental Physical Science Knowledge denotes accumulated physical science knowledge acquired by the child through informal sources, such as personal observations and conjectures, inter-action with parents, peers and siblings, and through books, media and a host of other non-instructional sources. In a nutshell, incidental physical science knowledge is any physical science information possessed by the child through non-instructional sources.

Urban and Non-urban Areas are characterized for the purpose of this study only by the following referents:

a) An urban area is a town which has:

- i) a population of 25, 000 or more
- ii) electricity and pipe-borne water supply
- iii) television services, and
- iv) public libraries.

b) A non-urban area is a town characterized by the following:

- i) a population of under 25, 000
- ii) non-availability of electricity and pipe-borne water supply
- iii) absence of television services, and
- iv) non-availability of a public library.

Headmaster is the designation for the head of an elementary school in Nigeria. The closest U.S. designation for the headship of such an institution is that of "Principal."

Primary Classes Four, Five and Six: These are grades four, five and six in elementary schools in Western State of Nigeria. Children in these grades fall into the age bracket of nine through eleven years.

Piaget-like Tasks: Piaget-like tasks can be defined as simple experiments which can be used to study child's thought and reasoning.

For example, a study which is interested in the child's thought concerning conservation of mass may make use of a rubber band in the following fashion: The rubber band is first shown and described to the child as a material made of rubber. He is then told that the rubber band can be stretched by pulling. On stretching the rubber band, the child is asked whether the stretched rubber band still has the same amount of rubber now as it had before stretching; or whether it now has less or more amount of rubber than it had before stretching. In the event of a correct response from the child, the experimenter will then ask the child to support his answer with logical reason(s).

Conservation: According to Beard, conservation is "invariance of quantity, e.g. of substance under change of shape, of length on change of direction or position, etc."[32]

Better-than-Chance Knowledge: A child possesses a better-than-chance knowledge of a subject if his score on a multiple choice test which is designed to assess his knowledge in the subject is "significantly"

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[32] Op. cit., p. ix.

higher than what he is expected to score by mere guesswork alone. For example, in a sixteen-item test, with four alternatives for each item, a child has a chance of scoring four points by guessing; but if he scores eight points which on statistical analysis is found to be statistically significant over the chance score of four, the child is said to possess a better-than-chance knowledge of the subject.

CHAPTER II

REVIEW OF LITERATURE

This chapter contains a review of pertinent literature dealing with studies related to incidental science learnings and Piaget's work.

2.1 Stuaies related to Incidental Science Learnings

From time immemorial, man had been able to pass down his culture and civilization from one generation to another through informal, non-school means. Even today, people in both developed and developing societies of the world still use informal methods in transmitting culture and knowledge to their young ones. In addition to this fact, the child also learns "spontaneously" about his environment as summarized below in the words of Stendler:[33]

> In the process of living and adjusting to his environment, the child has been dealing with such phenomena as time, matter, space, light, heat, motion and electricity...[34]

Literature search revealed an evidence and measurability of incidental science learnings. As it might be expected, there are as

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[33] Celia Stendler, The Developmental Approach of Piaget and Its Implications for Science in the Elementary Schools (New York: The Macmillan Science Series, 1966).

[34] Ibid., p. 19.

many methods of measuring incidental science learnings as there are available pertinent studies. However, the numerous methods can be classified into:

(a) Pencil-and-paper methods— involving standardized test and/or tests constructed by investigators,

(b) Questionnaire methods—including both structured and unstructured interviews, and

(c) Projective methods— involving the use of non-verbal or pictorial instruments. The different shades of these methods, the incidence and measurability of incidental science learnings are evident from the studies reviewed below.

In 1956, Schenke[35] in studying "information sources children use" made use of an interview method he described as a "semi-non-directive interview" method to elicit responses from his subjects concerning their out-of-school science learnings. His findings confirmed the existence of incidental science learnings in that he found that:

> In almost half the instances... children learned their science knowledge and beliefs with no assistance other than incidental help from other people. The first and second grade children in this study had a wide knowledge of the physical environment.[36]

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[35] L. Schenke, "Information Sources Children Use," Science Education, 40, pp. 235-38, April, 1956.

[36] Ibid., p. 235.

Two years later, Young[37] carried out a study titled "Atomic energy concepts of children in the third and sixth grades" with seventy-five third graders and sixty-eight sixth grade children. She used an interview method to elicit responses from her third grade subjects while the same information was solicited from her sixth grade subjects by means of a pictorial questionnaire. She found that many a third and sixth grader possesses knowledge about the concept of atomic structure and the use of atomic energy which they claimed to have gained incidentally through television; and she observed that "children do gain many concepts from out-of-school experiences."[38] In the light of her findings, she has the following advice to offer to both science educators and elementary school science teachers:

> In planning science experiences, it is necessary to determine 'science readiness'... Classroom organization must provide for exploration of abstract concepts by those children who already have basic understandings derived from the out-of-school experiences... The elementary school teacher is challenged to discover these concepts and to provide experiences which will develop further understandings.[39]

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37 Doris Young, "Atomic Energy Concepts of Children in the Third and Sixth Grades," School Science and Mathematics, 58, pp. 535-9.

38 Supra., p. 536.

39 Supra., p. 538.

In 1960, Chotkowska[40] studied "incidental science learnings" among elementary pupils in selected parochial schools in Manhattan, Bronx and Richmond. And in order to:

> measure...the amount of incidental science learnings acquired by pupils who had been without formal instruction in science...and examine the relationships which might exist between science achievement derived from incidental education and certain factors...[41]

such an achievement in health and safety, intelligence and verbal ability, Chotkowska subjected her 600 subjects to a battery of standardized tests and a questionnaire. The battery of tests was the form AA of California tests in Social and Related Sciences, part III. And using the standardized tests and the questionnaire, she found that her subjects were familiar with more than fifty percent of the concepts sampled; and that there are substantial relationships between the acquisition of incidental science learnings and the factors identified above. On the basis of her findings, she reported that:

> Science knowledge acquired incidentally [by her subjects] is not limited to animal and plant life; it includes some understanding of the solar system, the conservation of resources, development of power and the improvement of work.[42]

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[40] Sister Mary Chotkowska, "An investigation of Incidental Science Learnings with a Study of their Relationship to Certain Factors," (unpublished Ph. D. dissertation, Fordham University, 1960).

[41] Ibid., p. 4.

[42] Ibid., p. 137.

She recommended, among other things, that the "significant role of incidental science learnings should be recognized in educational programming."[43]

Inbody[44] set a two-pronged goal for himself in his study of "the understandings of selected physical phenomena possessed by suburban kindergarten children." His goal was:

> 1) To determine young children's understandings of selected physical phenomena, and
> 2) To determine if typical instructional experiences were appropriate, too difficult, or too easy for first grade children.[45]

To ac,.ieve his goal, Inbody analyzed the first and second grade science textbooks of eight current elementary school science series and from his analysis he devised a research instrument based on sixteen physical phenomena he gleaned from the science textbook series. And using a method he designated a "demonstration-interview technique," he subjected fifty kindergarten children, randomly selected from eighteen classrooms in three school districts, to his instrument. In summary, he has this to say about his research methodology:

> A demonstration-interview technique was used for collection of data. Demonstrations and pictures were presented and the children's explanations of the various events elicited.

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[43] Ibid., p. 138.

[44] Donald Inbody, "The Understandings of Selected Physical Phenomena possessed by Suburban Kindergarten Children," Dissertation Abstracts, Vol. 22, pp. 3950-51, 1962.

[45] Ibid., p. 3950.

> The children were interviewed individually by the investigator, and each interview was tape-recorded.[46]

He found that three of the sixteen phenomena his subjects were tested on were well understood by them; and he concluded that:

> Children's understandings of [the] phenomena appeared to be such that further instruction about them [in the first grade] is repetitious for most children. These [the physical phenomena] were: 1) rain is water, 2) wind can do work, and 3) sun and wind speed evaporation.[47]

Kerns[48] reported his findings concerning "a study of the differences of comprehension that pupils in Colorado elementary schools have of twenty selected science words" two years after Inbody's. He reported that his 925 subjects per grade in selected elementary schools throughout Colorado were exposed to an inventory of twenty science words he devised according to the following criteria:

> That they are: (1) representative of five broad areas of science, (2) presented in organized science courses now being taught, (3) socially significant, and (4) associated with current scientific research.[49]

The twenty science words selected for use in the investigation are, "atom, bacteria, cell, cosmic ray, energy, gene, gland, hormone

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[45] Ibid., p. 3950.

[46] Ibid., p. 3950.

[47] Ibid., p. 3951.

[48] Leroy Kerns, "A Study of the Differences of Comprehension that Pupils in Colorado Elementary Schools have of Twenty Selected Science Words," Dissertation Abstracts, vol. 24, pp. 3641-12, 1964.

[49] Ibid., p. 3641.

ionosphere, jet, molecule, planet, protein, satellite, seismograph, space, time, vaccine, virus and X-rays."[50] After analyzing the responses of the pupils to statements about the words, he found "no significant difference in the understanding of the selected words between groups with and without formal science classes."[51] This, among other things, led him to conclude that "in general, Colorado's elementary school children regardless of sex, community background, size of school districts, and whether or not they have studied science in school have considerable understanding in science, and could profit from skilled science instruction and carefully planned curriculum."[52] He also indicated that because of children's interest in their environment, "various areas of science" become what they can come to grips with even "before these areas become a part of their formal study."

Helfrich[53] carried out a "descriptive study of certain science learnings known by entering kindergarten children." He identified three goals of his study as:

> 1) To ascertain which science learnings children might be exposed to in grade one, 2) to determine the ability of entering kindergarten children to cope with the scientific

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[50] Ibid., p. 3641.

[51] Ibid., p. 3642.

[52] Ibid., p. 3642.

[53] John Helfrich, "A Descriptive Study of Certain Science Learnings Known by Entering Kindergarten Children," Dissertation Abstracts, Vol. 25, pp. 232-33, 1964.

> learnings so determined, [and] 3) to determine the entering kindergarten child's ability to recognize certain scientific apparatus when it was presented to them.[54]

For the first and second goals of the study, Helfrich analyzed the content of selected first grade science textbooks and interviewed his kindergarten subjects with the aid of "pictures which depicted the learnings so determined." The third goal was explored by presenting "certain items of science apparatus... to [the kindergarteners] so that they might be named." He found that the kindergarteners possess measureable incidental science knowledge and that "fifty percent of the children were also able to induce a generalization from four separate elements presented in random order."

In a similar study, Olmsted[55] showed that:

> Children entering first grade already know most of what the conventional curriculum and the usual text material expects them to learn in that grade, and concludes that teaching in science needs to be much more profound at that level.[56]

Olmsted arrived at above conclusion after interviewing the kindergarteners about their knowledge of first grade science materials. He found, among other things, that entering grade one children are already

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[54] Ibid., p. 232.

[55] C. Olmsted, "An Inventory of Information beginning First Grade Children have concerning Certain Concepts Selected from First Grade Science Textbooks," (unpublished Ed.D. Dissertation, Colorado State College, 1963).

[56] Herbert Schwartz and Others, "A Summary of Elementary Science Studies, 1964-65," (Division of Science and Mathematics Education, New York University, 1966).

familiar with some of the materials covered by first grade science textbooks and that entering grade one children are familiar with much more physical science aspects than their teachers presumed. He, therefore, recommended that elementary school science teachers should go beyond the text treatment of physical science concepts.

Floyd[57] who was concerned with the "analysis of the knowledge of science of pupils prior to instruction ..." analyzed the science content in seventh grade curriculum in order to devise his research instruments which he called "science knowledge test and science application test." He then subjected his subjects drawn from grades five, six, and seven classes to the instruments. Analysis of the children's performance on the tests revealed that:

> ...[the] pupils already know a considerable amount of the content of seventh grade science text books prior to instruction...[58]

In more recent time, Fafunwa[59] carried out a study to determine "the nature of scientific concepts possessed by non-literate adults of Western State of Nigeria." In exploring some aspects of science concepts among non-literate adults of Western State of Nigeria, Fafunva made use of a "Scientific Concept Questionnaire" to

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57 Thomas Floyd, "An Analysis of the Knowledge of Science of Pupils prior to Instruction in the Seventh Grade," Dissertation Abstracts, Vol. 26; pp. 7176-77, 1966.

58 Ibid., p. 7176.

59 Babs Fafunwa, "A Study of Scientific Concepts of Non-Literate Adults of Western State of Nigeria," (Faculty of Education, University of Ife, Nigeria, 1971).

elicit responses from his 2,650 subjects. Data for the study were gathered by trained research assistants who were sent to different quarters of the State to interview a random sample of non-literate subjects. Among other things, his analysis of the responses of the subjects showed that:

> Non-literate adults of Western State of Nigeria possess a better-than-chance knowledge of scientific concepts concerning natural phenomena, [and] that the subjects of the study possess more knowledge of agriculture than any other aspect of natural phenomena."[60]

It is significant to note that the subjects of the study had never seen the inside of a school and so the findings of the study reinforced the idea of acquisition of incidental science knowledge more than any of the studies reviewed above. In conclusion, it may not be an exaggeration to assert that this review has achieved its purpose by focusing on the fact that the child is capable of acquiring science information and concepts incidentally.

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[60] Ibid., p. viii.

2.2 Studies related to Piaget's Theories of Cognitive Development

A literature survey of studies related to Piaget's theories of cognitive development is necessary at this juncture to place the Piaget-like portion of this study in a broader educational context. The work of Piaget and his coworkers has been having tremendous influence on science education thought for more than a decade now. For example, in 1972 alone "more than 24 studies related to Piaget's work in child developmental psychology"[61] were reported by science educators. Among other things, these studies were concerned with the replication and extension of Piaget's science-related tasks.

But before reviewing studies related to Piaget's theories in order to show the trend and importance of Piaget's work in science education, it would be necessary to first discuss Piaget's theories of developmental stages themselves. This would help in placing the studies in proper and w' 'r perspective. So, the discussion that follows is divided into two sub-sections— the first subsection deals with the theories while the second sub-section focuses attention on pertinent studies.

a. Piaget's theories of developmental stages: Perhaps, a good starting point of discussing Piaget's theories of stages in cognitive

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61 Joseph Novak, A Summary of Research in Science Education - 1972, (Ohio: The Ohio State University, Dec. 1973), p. 20.

development is to begin with a brief history of the man himself. Jean Piaget was born on August 9, 1896, at Neuchâtel, in Switzerland. From his own accounts,[62] he is always a hard working person and a keen observer of nature. At the tender age of ten, he observed a rare partly albino sparrow in a public park and wrote a one-page description of the sparrow. The description was good enough to merit its publication by a scientific journal. And that one-page note of his at the age of ten was the beginning of an active writing career. Since then, he has authored numerous articles and more than thirty books.

At the end of his high school education, he proceeded to the University of Neuchâtel where he received a baccalaureate degree in 1915 and a doctorate in biology in 1918. But it was not until two years after his doctoral degree that he was lucky to secure a job, which was to be his turning point in life, in Binet's laboratory in a Paris elementary school under Dr. Simon. Piaget was charged with the responsibility of standardizing Burt's reasoning tests on Parisian children in the laboratory. In his oral autobiography,[63] Piaget admitted that it was during his stay with Simon that he became increasingly interested in child's thought. As Flavell[64] puts it: [He was] "fascinated not with the

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[62] Jean Piaget, "An Autobiography and List of his Major Published Works," in Jean Piaget, The Man and His Ideas, by Richard Evans (New York: E. P. Dutton and Co., Inc., 1973), pp. 105-175.

[63] Ibid., pp. 105-175.

[64] John Flavell, The Developmental Psychology of Jean Piaget, (New York: D. Van Nostrand and Co., Ltd., 1965), p. 3.

psychometric and normative aspects of the test data [of the Paris laboratory] but with the processes by which the child achieved his answers - especially his incorrect answers." Piaget himself acknowledged this fact by saying:

> ...I engaged my subjects in conversations patterned after psychiatric questioning, with the aim of discovering something about the reasoning process underlying their right, but especially their wrong answers.[65]

He was so intrigued by children's answer to some of the test tasks that he continued to analyze their verbal reasoning concerning a variety of simple manipulative tasks for over two years. This experience turned out to be a landmark and a turning point in Piaget's life as he himself admitted:

> I noticed with amazement that the simplest reasoning task involving the inclusion of a part in the whole or the coordination of relations or the "multiplication" of classes (finding the part common to two wholes) presented for normal children up to the age of eleven or twelve difficulties unsuspected by the adult. Without Dr. Simon being quite aware of what I was doing, I continued for about two years to analyze the verbal reasoning of normal children...
> ...At last I had found my field of research...This marked the end of my "theoretical" period and the start of an inductive and experimental era in the psychological domain which I always had wanted to enter...[66]

And for the next twenty-five years, Piaget was busy "experimenting" with children to discover a pattern in their processes of thought.

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65 Op. cit., Jean Piaget, p. 119.

66 Ibid., p. 119.

The year 1947 saw the long sought-after thought pattern in his theories[67] of stages in cognitive development in his book titled "La Psychologie de L'Intelligence" published in France. He postulated four principal periods in his theories of developmental stages as:

1. A period of sensori-motor intelligence (a period between the ages of zero and two years),

2. A Period of preoperational stage or pre-conceptual thought (ranging between the ages of two to eight years),

3. A period of concrete operations (falling between the ages of eight and eleven to twelve years), and

4. A period of formal or propositional thought (during adolescence).

Piaget theorized that the order of these stages is constant and sequential. That is, the sensori-motor period precedes the preoperational stage which in turn has to be reached before concrete stage develops; and formal operations appear only after concrete operations have been achieved. He maintained in unequivocal terms that the constancy and sequentiality of the order of the stages are unalterable by environmental influences and experiences. He, however, suggested that children may differ in the ages they reach the different stages

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[67] Jean Piaget, Psychology of Intelligence, (New York: Littlefield, Adams & Co., 1972), p. 123.

according to their social environment and the like but that notwithstanding the order remains constant.

In his address to the McGraw-Hill conference on Ordinal Scales of Development held in Monterey, California in 1969, Piaget had this to say about the constancy and sequentiality of the order of his developmental stages:

> Each stage is necessary for the following one. If this were not the case, one would be in no position to talk of stages. Naturally, the ages at which different children reach the stages may vary. ... The order, however, remains constant.[68]

Piaget claimed that he arrived at this theory of developmental stages through experimentation with children involving the use of a method he termed "clinical method."[69] A few of his supporting experimental and observational studies deserve some attention at this juncture. For Piaget and his collaborators, the development of intelligence begins at the cradle of life and continues through the stages outlined above to maturity. Most of his studies at sensori-motor stage were done through careful observation of infants and toddler including his own children. He discovered that during the early period of this stage, a child's mental and motor activities are limited to only a number of

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[68] Jean Piaget, "The Theory of Stages in Cognitive Development" in Critical Features of Piaget's Theory of the Development of Thought, edited by Frank B. Murry, (New York: MSS Information Corporation, 1972), p. 122.

[69] This involves interviews with children; and the types of questions a child is asked about a particular activity are dictated by the previous responses of the child to earlier queries.

intelligenco-motor activities such as object-grasping and some rudimentary language development. Later in this stage, the child becomes more perceptive of his environment through his senses. In short, sensori-motor stage may be described as a period in child's development which begins with just a few reflexes at birth and ends when language and other symbolic ways of representing the world first appear.

The pre-operational stage which extends from the age of two to about eight years is so characterized because the child does not use "logical operations" in his thinking. In this respect, Stendler[70] identified three areas of child's weaknesses as:

> 1. The child is perceptually oriented; he makes judgments in terms of how things look to him...
> 2. The child centers on one variable only, usually the variable that stands out visually; he lacks the ability to coordinate variables... [and]
> 3. The child has difficulty in realizing that an object can possess more than one property and that multiple classifications are possible...[71]

The above categorization of child's modes of thought are supported by Piaget's experimental studies. For example, when he showed two rows of equal counters (one red and the other blue) to his pre-operational subjects, they acknowledged equivalence of the two rows of counters as long as the counters in one of the rows are not drawn

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[70] Celia Standler, The Developmental Approach of Piaget and Its Implications for Science in the Elementary Schools. (New York: Macmillan Science Series, 1966).

[71] Ibid., pp. 8-9.

closer or further apart from each other. When this was done, the subjects denied equivalence. Perhaps, a more fascinating example of child's thought in pre-operational period is his ideas about ages as found in the following writing of Piaget:

> ...If A was born before B, that does not mean that he is older and, if he is older, that does not exclude the possibility that B might catch up with him or even overtake him![72]

The second weakness of the child as identified by Stendler above could be illustrated by a simple Piagetian experiment.[73] Two identical glasses were filled with an equal number of beads by a subject who agreed that the glasses contained equal amounts of beads. He was then asked to empty the beads in one of the identical glasses into a differently shaped glass with the other filled glass left as a standard. And when the child was queried about the contents of the glasses, he denied equivalence saying that there are more beads than before because "it [the other glass] is bigger," or that there are fewer beads because "it is thinner,"[74] depending on the shape of the new glass.

The last of child's weaknesses as outlined above can be examplified by his conception of a simple mathematical expression:

$$A + B = C \text{ (where } A > B)$$

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72 Op. cit., Jean Piaget, p. 137.

73 Ibid., p. 129.

74 Ibid., p. 130.

When the child of pre-conceptual level is confronted with the problem above even in concrete terms such as "A" representing red beads and "B" representing blue beads, he is likely to deny reversibility, that is, he would deny that C = B + A. In the same vein, he is more than likely to say that "A" is greater than "C" because "there are more A's than B's."

But at concrete level of operation, the story is quite different. At this stage, the child is capable of using or manipulating concrete objects to arrive at correct perceptual judgments. Taba[75] characterized this stage as a period when:

> ...the child is able to make limited and tentative alterations in the environment and to perceive abstract relationships among the variables in the objects he manipulates. Thus, the capacity to think abstractly is expressed through the manipulation of objects.[76]

In the same vein, Piaget demonstrated that children in this period of mental development are capable of giving rational answers to queries about the equivalence of beads cited earlier. He reported[77] that children at this period are not only "conservers" on questions dealing with the bead experiment but also on a variety of other conservation tasks.

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75 H. Taba, et al., "Thinking in Elementary School Children," (unpublished Research Project, San Francisco State College, n. d.).

76 Ibid., p. 11.

77 Jean Piaget, Psychology of Intelligence, (New York: Littlefield, Adams and Co., 1972), p. 140.

And the children at this stage generally rationalize their answers by saying that since "nothing has been removed or added" equivalence must obtain irrespective of the number or kinds of transformations. Along with the development of conservation ability in children in this stage, Piaget[78] postulated that classification and seriation abilities are developed synchronously as well; and that conservation of quantity appears first followed by that of weights and that of volume last in the development of conservation abilities.

The formal operation level reaches fruition during adolescence. This period can be referred to as "hypothetico-deductive" period because the adolescent at this period is capable of arriving at an hypothetical solution based on abstract thinking without recourse to concrete objects. In summary, Piaget characterized this period as one in which:

> ...a matter of classing, serializing, enumerating, measureing, placing or displacing in space or in time, etc. ... [is done]...by formal operations...Formal operations, therefore, consist essentially of "implications" (in the narrow sense of the word) and "contradictions" established between propositions which themselves express classifications, seriation, etc.[79]

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[78] Ibid., pp. 146-147.

[79] Ibid., pp. 148-49.

The story of Piaget's theories of child developmental psychology would be incomplete if one fails to mention some of the criticisms of some of the outstanding critics of the theories. There are three major areas in which Piaget's work appears to be vulnerable, viz., 1) the development of the theories, 2) his methodology, and 3) his language idiosyncrasy. Many authorities, such as Baldwin, Bruner, Flavell and Vygotsky, in the field of cognitive development are critical of Piaget's theories because they feel that the theories are the result of "over-interpretation" of child's responses. Piaget is also criticized of not stating explicitly whether the data reported by him lead him to confirm a particular hypothesis or lead him to form a particular hypothesis which would have to be subjected to empirical studies for authentication. In the words of Baldwin:

> In many ways his [Piaget's] experimentation has been exploratory; he has been searching for understanding of children's thinking, rather than testing a particular hypothesis about it. We are never clear when he is doing which; sometimes he reports data as if they confirmed an hypothesis, when in fact the data led him to form the hypothesis.[80]

In short, Piaget is criticized for divorcing his theories from his data.

He, however, has a rejoinder for his critics on this aspect. In a foreword to Flavell's book titled "The developmental psychology of Jean Piaget," which he claimed to have "both a great pleasure and a great honor" to write, Piaget has this to say to his critics about his theories:

[80] Alfred Baldwin, Theories of Child Development, (New York: John Wiley and Sons, Inc., 1967), p. 298.

> ...as regards the entire first set of criticisms—the general trend of which is that... there is too wide a gap between the facts I describe and the theories I invoke—it could be argued that the difference between us [himself and his critics] stem from the fact that [their] approach is perhaps too exclusively psychological and insufficiently epistemological while the converse is true for me.[81]

As stated earlier, Piaget's methodological procedure is also an aspect of his work which is always criticized. His methodology is criticized for his habitual failure to give explicit description of what his testing conditions are and relevant information such as social background of his subjects. In short, he is criticized for the way he designs, executes and analyzes his empirical studies. Above all, his "clinical method" of eliciting responses from his subjects makes statistical comparison of the responses of his subjects impossible since his subjects were generally asked different questions even when the same problem is being tackled. The lack of "standardized" procedure makes his data almost unamenable to statistical analysis. In effect, his studies fail to show the effects of essential subject characteristics such as the "correlation between response level (stage) and age..."[82] It is pleasing to note, however, that work is afoot to make his studies amenable to statistical analysis. He reported in one of his recent writings that:

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[81] Jean Piaget in his foreword to Flavell's "Developmental Psychology of Jean Piaget," pp. viii-ix.

[82] Op. cit., Flavell, p. 432.

> As to the criticisms usually directed toward me regarding the qualitative method which we use in our intellectual development studies...it must...be said that our research is far from completed and that all sorts of controls, both statistical and nonverbal are currently in progress.[83]

The last but not the least criticism of Piaget's work stems from the lack of clarity in his style of writing. Many a reader complains that Piaget's accounts of his studies are generally too difficult to comprehend to say the least. And to drive home this clumsiness in Piaget's writings, Flavell cited the following Piaget's sentence as an example:

> In sum, we are dealing with a set of schemata whose dual nature stems from the fact that, whereas their structuring presupposes formal reasoning, they also derive from the most general characteristics of the structures from which this same formal thought arises [Inhelder and Piaget, in The Growth of Logical Thinking from Childhood to Adolescence, p. 106].[84]

To say the least the above quotation is a very difficult sentence, and it is just one of many such sentences which punctuate Piaget's writings.

All told, however, Piaget remains a "giant" and a force to be reckoned with in the field of child's cognitive development. His contribution to the field of cognitive development appears to be non-pareil in recent history. In fact, his contribution to modern educational thinking is acknowledged world-wide.

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[83] Jean Piaget in his foreword to Flawell's Developmental Psychology of Jean Piaget, p. ix.

[84] Op. cit., Flavell, p. 427.

b. Piaget-type studies: Because of barriers such as language, Piaget's work did not receive intensive attention it deserves from educational circles[85] in English-speaking nations of the world until the 1950's. But when some of the barriers were overcome, educators as well as science educators in English-speaking nations of the world studied Piaget's work with rapt attention. And since then, the two decades of studying Piaget's work by English-speaking educators had witnesses a great impact[86] not only in general educational thinking but in science education thinking as well in the United States, Canada, United Kingdom and some parts of Africa. For instance, numerous Piaget-type studies had been undertaken by science educators in these countries since the late 1950's.

Most of those studies could be classified under one of the following categories[87] identified by Novak.

a. Replication and Extension [of Piaget's studies],

b. Studies of the effect of Instruction on cognitive growth,

c. Cultural or hereditary influences on cognitive development, and

d. Correlation of school achievement or other abilities with Piagetian stages.

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[85] Op. cit., Novak, p. 20.

[86] Ibid.

[87] Ibid., pp. 20-23.

The studies reviewed below are meant to serve as indicators of past and current activities and thoughts in science education concerning Piaget's developmental psychology.

Replication studies carried out in Western countries such as Britain, Canada and the United States, and in non-Western countries of the world including some parts of Africa, have in general supported Piaget's theories of developmental stages as discussed below. In 1959, Hyde[88] carried out a cross-cultural study with Arab, European, Indian and Somali children. She obtained results similar to Piaget's in tasks involving seriation and classification. And in the following year, Lovell and Ogilvie[89] reported the results of their study with a large sample of English school children tested on tasks dealing with conservation of substance. This study, like its predecessor, confirmed Piaget's.

Of the Piaget-type studies reported in 1961, those reported by Dodwell, Elkind, Price-Williams and Smedslund are of special interest to this study because of their pertinence. Dodwell[90] who was interested in the child's development of number conservation used five, six and

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88 D. M. Hyde, An Investigation of Piaget's Theories of the Development of the Concept of Numbers, (unpublished doctoral dissertation, University of London, 1959).

89 K. Lovell and E. Ogilvie, "A Study of the Conservation of Substance in the Junior School Child," British Journal of Educational Psychology, 30, pp. 109-118, 1960.

90 P. C. Dodwell, "Children's Understanding of Number Concept: Characteristics of an Individual and of a Group Test," Canadian Journal of Psychology, 15, pp. 29-36, 1961.

seven-year-old Canadian children for his study. His finding complimented Piaget's to a great extent. He, however, sounded a warning note concerning Piaget's conclusions about the child's number conservation ability: "[That] while Piaget is on the whole correct in his description of the child's understanding of numbers, the pattern of development is neither as neat nor as rigid as he would have us believe."[91]

Elkind carried out three separate studies concerning conservation tasks with American children aged between four and fifteen years. In the first[92] of his series of studies, he tested children aged four to seven years, about their ideas of conservation of continuous and discontinuous quantities. He found that conservation ability is age-dependent and that the conservation of continuous quantity appears to be a more difficult task than that of discontinuous quantities. And working with five-to-eleven-year-olds, Elkind[93] found again that conservation ability is age-dependent and that the acquisition of conservation abilities follows the pattern postulated by Piaget: Conservation of quantity first, then that of weight and that of volume last. In a further replication study, Elkind[94] tested about 500 children aged twelve to fifteen years in both junior and

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[91] Ibid., p. 35.

[92] David Elkind, "The Development of Quantitative Thinking," Journal of Genetic Psychology, 98, pp. 36-46, 1961.

[93] David Elkind, "Children's Discovery of the Conservation of Mass, Weight and Volume: Piaget Replication Study II," Journal of Genetic Psychology, 98, pp. 219-227, 1961.

[94] David Elkind, "Quantity Conceptions in Junior and Senior High School Students," Child Development, 32, pp. 551-560, 1961.

senior high schools. His findings at those levels also supported Piaget's to a large extent.

In a study similar to the one conducted by Dodwell with Canadian children, Price-Williams[95] tested forty-five illiterate Tiv children in Northern part of Nigeria on conservation tasks dealing with both continuous and discontinuous quantities using locally available objects. Once again, Piaget's theory of progression in conservation abilities according to age was upheld.

Unlike the studies reported so far, Smedslund[96] tried to accelerate the child's cognitive development in conservation of weight through instruction. He tutored his subjects that the weight of a lump of plasticine remains the same irrespective of change in its shape. He found that instruction could accelerate the acquisition of conservation ability. But although his trained subjects did well on subsequent tests dealing with conservation of weight, it was not clear from his report whether the subjects' knowledge in this field is transferable to other conservation tasks.

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[95] D. R. Price-Williams, "A Study concerning Concepts of Conservation of Quantities among Primitive Children," in Cross-cultural Studies, edited by Price Williams (New York: Penguin Books, 1969), pp. 201-210.

[96] J. Smedslund, "The Acquisition of Conservation of Substance and Weight in Children II: External Reinforcement of Conservation of Weight and of the Operation of Additions and Subtractions," Scandinavian Journal of Psychology 2, pp. 71-84, 1961.

The year 1962 saw a sustained interest in science-related Piaget's studies. Dodwell[97] investigated the relationships between the development of the concepts of number and classification, while Lovell, Mitchell and Everett[98] studied the relationships among a number of classification and seriation tasks. Dodwell's study yielded positive correlations between the children's answers to classification problems and items on number tasks. The correlations were, however, found to be too low to be significant. In their own case, Lovell and his coworkers found that the attainment of seriation and classification abilities in children is synchronous.

A year after his first study of illiterate Tiv children in Nigeria, Price-Williams[99] carried out another study with some Tiv children by comparing illiterate Tiv children with school-going Tiv children of comparable ages in the same area. He found, using local materials, that there was no significant difference between the two groups of children.

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[97] P. C. Dodwell, "Relations between the Understanding of the Logic of Classes and of Cardinal Number in Children," Canadian Journal of Psychology, 16, pp. 152-160, 1962.

[98] K. Lowell, B. Mitchell and I. Everett, "An Experimental Study of the Growth of Some Logical Structures," British Journal of Psychology, 53, pp. 175-188, 1962.

[99] D. R. Price-Williams, "Abstract and Concrete Models of Classification in a Primitive Society," British Journal of Educational Psychology, 32, pp. 50-61, 1962.

Jacqueline Goodnow[100] who "exported" the work of Piaget to Hong Kong, reported that "the most striking result is the very real and close similarity in performance among boys of different nationalities and education."[101] Her subjects comprised children of European and Chinese ancestries with varied schooling experience.

A short time after the two earlier studies by Price-Williams concerning the performance of the African child on Piagetian tasks, there appears to be a renewed interest in studies dealing with the performance of the African child on Piagetian tasks. The studies by Greenfield, Almy, Etuk, Beard, Vernon, Lloyd and Otaala are worthy of attention in this respect. Greenfield's[102] study of the Wolof children of Senegal showed that there is a significant difference between urban and rural children in favour of the urban children in their (the Wolof children's) performance on conservation tasks. And Almy's[103] study of the performances of Kampala children on conservation, seriation and classification tasks showed that the children have more rapid progress in

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[100] Jacqueline Goodnow, "A Test of Milieu Effects with Some Piaget Tasks," Psychological Monographs, 76, pp. 1-22, 1962.

[101] Ibid., p. 19.

[102] Patricia Greenfield, "On Culture and Conservation," in Jerome S. Bruner, et al. Studies in Cognitive Growth, (New York: Wiley and Sons, 1966), pp. 225-256.

[103] Millie Almy, The Usefulness of Piagetian Methods for Early Primary Education in Uganda: An Exploratory Study, (unpublished report, 1967).

understanding seriation than they have in classification and conservation. Like Almy, Etuk[104] studied the conservation, classification and seriation abilities of some African children. She administered a number of Piaget-type tasks to 110 Yoruba children aged six to eight in classes one to three of an elementary school. Her analysis upheld Piaget's theory of simultaneous development of conservation, seriation and classification abilities to a large extent. Beard's[105] investigation was carried out among Ghanaian children. Her findings agreed with Piaget's findings.

In 1969, Vernon[106] reported a study of a group of fifty African boys in an Ugandan urban school. The children whose average age was about eleven were tested in a variety of tasks including the conservation of liquid, plasticine, number, length and area. Even though the investigation was conducted in English, Vernon reported that Piagetian developmental trend was evident in the children's responses. He, however, stated that "magical beliefs" among the children might have been responsible for the children's low scores on the conservation

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[104] Elizabeth S. Etuk, The Development of Number Concepts among the Yoruba-speaking Nigerian Children, (unpublished doctoral dissertation, Teachers College, Columbia University, 1967).

[105] Ruth Beard, "An Investigation into Mathematical Concepts among Ghanaian Children," Teacher Education in New Countries, 9, pp. 132-145, 1968.

[106] Philip Vernon, Intelligence and Cultural Environment, (London: Methuen, 1969).

tasks. That notwithstanding, he admitted that the use of English rather than the children's own vernacular might have adversely affected their scores. In another study with Yoruba-speaking subjects, Lloyd[107] studied, among other things, "the effect of familiar and alien materials" on the conservation ability of three-to-eight year-old Yoruba children. She made use of "two female Yoruba University students" as the interviewers of her subjects. She found that "performance [of the subjects] was similar with familiar and with alien materials, although it improved with practice."[108]

In 1973, Obaala[109] carried out a Piaget-type study among 160 boys and girls in a rural part of Uganda. The study was carried out to determine "the level of thinking of the Iteso Primary School Children in Uganda; and [to determine] whether abilities involved in conservation, classification, and seriation develop at the same rate."[110] Although the study failed to support the theory that conservation, classification and seriation abilities develop synchronously in children, it did conform to a very great extent with corresponding Piagetian tasks with Swiss children.

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[107] Barbara Lloyd, "Studies of Conservation with Yoruba Children of differing Ages and Experience," Child Development, 42, pp. 415-428, 1971.

[108] Ibid.

[109] Barnabas Otaala, The Development of Operational Thinking in Primary School Children, (New York: Teachers College Press, 1973).

[110] Ibid., p. 22.

CHAPTER III

RESEARCH METHODOLOGY

This chapter deals with the procedural details of this study. In a nutshell, the paragraphs below describe the multi-stage procedure employed in gathering and analyzing the data for this study.

3.1 Construction of Research Instruments

The two instruments used in collecting data for this study were constructed by the investigator due to the simple fact that none of the commercially available tests were found to be suitable for the study in terms of their content and language. For example, most of the tests[111] surveyed were found to contain elements such as concepts of snow, climatic changes in the United States, and some aspects of the U. S. space programme which are likely to be unsuitable for the population of this study. In addition, other sources consulted such as the Ministry of

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[111] The tests surveyed include the following: (1) Metropolitan Achievement Tests: Science, Intermediate - Grades 5 and 6; (2) Science Test for New York State Elementary Schools, Forms A & B; (3) Physical Science Aptitude Examination (State University of Iowa,) Grade 7; (4) Survey Tests in Physical Science; California Survey Series: Grade 7, Form 1; and, (5) Stanford Achievement Test, Intermediate Grades 5 and 6, Forms W1 and WII.

Education, Western State of Nigeria, Ibadan, Nigeria and West African Examinations Council, Lagos, Nigeria, were not found helpful either. The two instruments of study were, therefore, developed by the investigator with the cultural background of the population of study in mind. For the sake of convenience, the two instruments were named Physical Science Knowledge Test and Interview Guide for Piaget-like Tasks. The following sub-sections deal with the details of the construction of the two instruments.

(a) Physical Science Knowledge Test

The construction of the first draft of this test[112] followed a thorough examination of the so-called "science-related" subjects[113] in the elementary school curriculum of the Western State of Nigeria by the investigator. After a thorough study of the content of the "science-related" subjects, the investigator developed a forty-item test whose items dealt specifically with only aspects of elementary physical science. It is significant to note that none of the forty items of the test were derived from the content of the syllabus of the "science-related"

[112] For inspection of the items of this test, the reader is referred to Appendix I.

[113] These "science-related" subjects which are called nature study, gardening and hygiene, deal mainly with selected topics in plants, animals, and the care of the human body. To give the reader an idea of the content and scope of these subjects, the entire syllabus for primary classes one through six and some past final examination questions on these subjects for primary class six pupils are reproduced in Appendix VII.

subjects, since the test was meant to probe into the nature of incidental physical science knowledge possessed by the population of this study. The vocabulary of the test and its sentence structure were such that the four elementary school teachers consulted in the State during the development of the test were of the opinion that the language structure of the test was within the realm of understanding of the population of this study. In addition to the above criterion, it is also important to note that the items selected for the test were such that the population of the study could be expected to be familiar with due to the fact that the test was constructed of elements derived from the population's cultural environment.

It is pertinent at this juncture to discuss the nature of the forty items of the test. The test was divided into three broad areas, viz., physical phenomena, natural phenomena, and domestic utilities. The first twenty items of the test dealt with physical phenomena, while questions twenty-one to thirty-one dealt with natural phenomena, and the rest of the items of the test centred around domestic utilities. Among other things, the first twenty questions of the test covered some selected aspects of electricity, air and water. For example, this portion of the test was interested in the photothermal effects of electricity, how electricity can be transferred from place to place and what it is capable of doing, the uses of air and the fact that air occupies space; change of state and the notion of water as a solvent for some substances.

The natural phenomena section of the test examined the causes of eclipses, day and night, the source of moon energy, the formation of rain and rainbow, the nature of the sun and the concept of thunder and lightning.

Questions thirty-two to forty of the test dealt with domestic utilities such as tap water, telephone, television, refrigerator and radio. Only the uses of the various utilities were surveyed in this section.

After the construction of the test, copies of it were sent to four elementary school teachers from four randomly selected elementary schools in the State for an item-by-item inspection of the test. These teachers constituted a panel of judges whose duty was to ensure that none of the items of the test contained elements which are directly related to elementary school curriculum in the State. Details of the outcome of their deliberations are contained below in the section dealing with the validation of research instruments.

(b) Interview Guide for Piaget-like Tasks

Like the construction of the physical science knowledge test, the construction of the first draft of the interview guide for Piaget-like tasks took cognizance of the nature of the population and subject matter of the study. The fifteen items of the first draft which was later expanded to twenty items to form the second draft of the guide were constructed with two criteria in mind: (i) Only "science-related"

Piaget-like activities were selected for the guide[114] in order to deduce any relationship which might exist between the amount of incidental science knowledge possessed by the population of the study and their performance on the Piaget-like tasks, and (ii) the activities were designed in such a way that all the apparatuses used for them were derived from the environment of the population of this study.

The twenty items of the second draft of the guide were classified into two broad sections, A and B. Section A dealt with the concepts of conservation of distances, length, substance, and weight, while Section B dealt with the concepts of air, classification, measurement, sinking, speed, time, and gravity. For validation purposes, copies of the second draft of the guide were given to a panel of three psychologists in the Faculty of Education, University of Ife, Nigeria. The outcome of their deliberations are described below under sub-heading dealing with the validation of the interview guide for Piaget-like tasks.

3.2 Validation of the Physical Science Knowledge Test

As stated earlier, copies of the first draft of the forty-item test were sent to four elementary school teachers whose duty was to assist the investigator in establishing whether each item of the test

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114 See Appendix V for the inspection of the items of the first and second drafts of the guide.

possessed both face[115] and content[116] validities. After studying the items of the test for a week, the four elementary school teachers had a conference with the investigator. During this conference, the forty-item test was reduced to a thirty-item test[117] by the unanimous agreement of the participants. The ten items deleted from the first draft of the test were deleted for the following reasons: Question 3 in the first draft was deleted because it was a duplication of some of the questions dealing with utilities, while questions 5, 11, 17, 19, 20, 23, 30 and 31 were deleted because they were thought to be outside the informal experiential domain of the population of study; and finally question 15 was deleted because it was feared that the subjects of this study might utilize their knowledge in Arithmetic to solve it.

In order to further validate the test, item analysis of the thirty-item test was carried out by the investigator. The thirty-item test was administered on primary classes six, five and four pupils in an urban

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[115] According to Selltiz and others, "...measures, which focus directly on behavior of the kind in which the tester is interested, are often said to have 'face validity;' that is, the relevance of the measuring instrument to what one is trying to measure is apparent 'on the face of it.'"

[116] According to Dalen and Meyer, "...to establish content validity, the test constructor analyzes the content of the factor that he intends to appraise and structures a representative instrument to measure the various aspects of that content."

[117] This second draft of the physical science knowledge test can be inspected in Appendix II.

school in the State. Although the investigator took special care in the choice of vocabulary for the test and the four participating elementary school teachers were of the opinion that the vocabulary of the test was within the level of understanding of the population of this study, the investigator discovered to his dismay[118] that primary class four pupils in the sampled school could not read the test items let alone answer them. This problem was overcome by translating the test to Yoruba, the language of the people of Western State of Nigeria. Armed with the Yoruba version[119] of the test, the investigator revisited the urban school and administered the test to fifty-four primary classes four, five and six pupils who did not take the English version of the test. In addition to the above, fifty primary classes four, five and six pupils in a rural school were exposed to the test bringing the total number of elementary school pupils exposed to the test to one-hundred-and-four. Item analysis was then carried out on the scores obtained by the pupils in order to deduce both the level of difficulty and the discriminating power of each item of the test. A summary of the outcome of the item analysis of the test results is given below:

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[118] On second thought, however, the inability of the primary class four pupils to read the English version of the test does not surprise the investigator, since Yoruba is the medium of instruction in Western State of Nigeria for the first three years of schooling and primary class four is the threshold for using English as a medium of instruction in elementary schools in the State. No doubt, pupils of this class are bound to have limited vocabulary in English.

[119] See Appendix III for this version.

TABLE 4

RESULT OF THE ITEM ANALYSIS OF THE SCORES OF THE SAMPLE ON THE PHYSICAL SCIENCE KNOWLEDGE TEST

Item Number	Level of Difficulty $*p=\frac{Nr}{Nt} \times 100$	Discriminating Power $**D = \frac{U-L}{N}$
*** (1)	55.6	0.384
2	77.0	0.423
(3)	29.0	0.346
(4)	72.0	0.460
5	16.3	0.038
(6)	54.5	0.575
(7)	62.2	0.540
8	20.4	0.000
9	77.2	0.230
(10)	69.5	0.384
11	27.2	0.115
12	7.9	0.038
(13)	28.4	0.346
14	39.8	0.154
15	17.8	0.308
(16)	46.5	0.230
17	30.8	0.038
(18)	29.2	0.346
19	83.0	0.540
(20)	39.8	0.690
21	19.6	0.115
22	27.2	0.000
(23)	49.0	0.451
24	75.5	0.655
(25)	73.6	0.615
(26)	50.5	0.460
(27)	37.2	0.615
(28)	72.0	0.730
(29)	39.4	0.451
30	76.0	0.550

Key to Table 4

* "P" stands for level of difficulty of a test item.

"N_r" stands for the number of subjects that got the item right.

"N_t" stands for the total number of subjects.

** D — Discriminating power of a test item.

U — Number of subjects who got the item right in 25% upper group.

L — Number of subjects who got the item right in 25% lower group.

N — Total number of subjects in the 25% upper or lower group.

*** The circled items are the sixteen items selected on the basis of the results of the item analysis.

Table 4 above gives the summary of the outcome of the item analysis of the test results[120] of the one-hundred-four pupils exposed to the second draft of the physical science knowledge test. Using Ahmann's definition[121] in selecting items which possess

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[120] Appendix VIII contains scores of the 104 subjects in the thirty-item test in ascending order of magnitude. The mean score of the subjects on the test and the average difficulty value of the entire test are also contained in this appendix.

[121] Ahmann suggested that desirable test items cluster around 50% level of difficulty and that "... those D-values [discriminating power value] which exceed +0.40 are good, those between +0.40 and +0.20 are satisfactory, and those between +0.20 and 0.0 are poor." For further details, see J. Stanley Ahmann, Testing Student Achievements and Aptitudes (Washington: The Center for Applied Research in Education, Inc., 1968), pp. 35-37.

adequate levels of difficulty[122] and adequate discriminating power values,[123] items 1, 3, 4, 6, 7, 10, 13, 16, 18, 20, 23, 25, 26, 27, 28 and 29 were selected from the second draft of the test to constitute the third draft of the physical science knowledge test for this study. It should be noted that all the sixteen items selected fell within the range of twenty-five to seventy-five per cent of the computed levels of difficulty and also within the +0.750 and +0.200 of the computed discriminating powers. These item selection criteria are in consonance with Ebel's[124] suggestion that "in the case of a well-developed achievement test, more than 50% of the test items should have D-values exceeding +0.40; [and] less than 40% should have D-values between +0.40 and +0.20."[125] It is significant to note that ten of the sixteen items selected have D-values exceeding +0.40 and the remaining six items have D-values between +0.40 and +0.20. The actual percentages of the two sub-sets of the test items are 62.5% and 37.5% respectively.

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[122] Level of difficulty or difficulty value is a statement of a test item's difficulty, usually expressed as the percentage of individuals in a given group answering the item correctly.

[123] Test item discriminating power: According to Ahmann, "...a test item possessed adequate discriminating power when it is capable of differentiating between superior and inferior students."

[124] Robert L. Ebel, "Procedures for the Analysis of Classroom Tests," Educational and Psychological Measurements, XIV, (Summer, 1954), pp. 352-364.

[125] J. Stanley Ahmann, Supra, p. 37.

The sixteen selected test items were then arranged according to their levels of difficulty with the easiest item first and the most difficult item last. Therefore, item 25 in the second draft became the first item of the third draft while item 13 of the second draft became the last item (item 16) of the third draft.

It is not out of place at this point to discuss the nature of the third draft of the physical science knowledge test.[126] Like its predecessors (first and second drafts), the test items of this instrument can be classified under three broad headings, viz., physical phenomena, natural phenomena and utilities. Questions 1, 3, 8 and 12 of this draft dealt with utilities such as telephone, refrigerator, television and radio, while questions 2, 4, 10, 11 and 14 dealt with natural phenomena such as the chief source of light energy in the day, occurrence of iron, the moon, rainbow and rain formation. The physical phenomena aspects were covered by questions 5, 7, 9, 13, 15 and 16. Question 5 dealt with the principle of evaporation, while questions 7 and 9 were concerned with the change of state of water and tap water as a source of pure water respectively. And finally, questions 13 and 15 dealt with concepts of air and magnetism respectively while question 16 focused on the reason why rain water is purer than water from the well.

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[126] See Appendix IV for both the English and Yoruba versions of this test.

3.3 Validation of the Interview Guide for Piaget-like Tasks

In order to establish the content validity of this instrument, copies of the twenty-item guide were given to three psychologists for an item-by-item examination of the guide. Their assignment was to select suitable tasks for Piaget-like experiments for the population of this study from the twenty items of the guide. Like the validation of the physical science knowledge test, the consensus of opinions of members of the panel was needed for any item before it could be deemed suitable for the study by the investigator. After their deliberations, the twenty-item guide was reduced to a ten-item guide.[127] Questions 3, 6, 7, 8, 10, 11, 12, 15, 17 and 20 were unanimously rejected by the members of this panel for a variety of reasons chief among which was the reason that the activities contained in these questions are not suitable for the population of this study in terms of the complexity of the activities or the concepts involved. The members of the panel also suggested that some of the statements of the ten questions (questions 1, 2, 4, 5, 9, 13, 14, 16, 18 and 19) selected should be modified a little bit. For example, the material section in question 5 was modified to read "two equal pieces of chalk," instead of "a piece of chalk." It was the contention of the members of the

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[127] This third draft of the guide is reproduced in Appendix VI.

panel that the second piece of chalk would serve as a reference material after a subject might have powdered up one of the pieces of chalk.

3.4 Reliability of the Physical Science Knowledge Test

The reliability of this instrument (the third draft of the test) was determined by the split-half method using the Spearman-Brown Prophecy formula. This involved finding the correlation coefficient between two halves of the test and estimating the reliability of the whole test by applying the Spearman-Brown formula. This was accomplished by administering the sixteen-item test to 120 pupils selected as follows:

TABLE 5

SAMPLE CHARACTERISTICS FOR RELIABILITY TESTS FOR THE TWO RESEARCH INSTRUMENTS

Names of Schools	Primary class six		Primary class five		Primary class four		
	Boys	Girls	Boys	Girls	Boys	Girls	Total
1. Baptist Central (Urban)	10	10	10	10	10	10	60
2. L. A. School (Non-Urban)	10	10	10	10	10	10	60
Total	20	20	20	20	20	20	120

The scores of the 120 subjects were then subjected to statistical analysis[128] in order to determine the reliability coefficient of the instrument. Correlation coefficient between the two halves of the test was found to be 0.445 and a reliability coefficient of 0.616 was obtained for the whole test on applying Spearman-Brown formula.

3.5 Reliability of the Interview Guide for Piaget-like Tasks

The reliability of this instrument was determined by procedure similar to the one used in the determination of reliability of the physical science knowledge test. The determination of the reliability coefficient for this instrument involved the introduction of the same 120 subjects to the activities of the third draft of the interview guide. The responses of the subjects sampled were noted and then analyzed statistically to determine the reliability of the instrument. Correlation coefficient between the two halves of the instrument was found to be 0.529, while a value of 0.692 was obtained for the reliability coefficient[129] of the whole instrument after applying Spearman-Brown formula.

3.6 The Final Research Instruments

Having carried out necessary validation exercises on the two research instruments and having obtained what could be regarded as

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[128] See Appendix IX for pertinent results of the reliability test for the instrument.

[129] See Appendix IX for more detailed results.

reasonably satisfactory reliability coefficients[130] for the instruments, the third drafts of the physical science knowledge test and the interview guide were adopted for this study. Both the English and Yoruba versions of the final physical science knowledge test are contained in Appendix IV as the third draft of the instrument. The third draft of the guide in Appendix VI also served as the final guide for the Piaget-like portion of this study.

It is germane at this point to outline the contents of the two research instruments. First, the physical science knowledge test. The sixteen items of the physical science knowledge test were designed to examine the sample's understandings of the following concepts.

1. That the telephone is used to communicate verbally with other people.

2. That sun is the chief source of light energy during the day in Nigeria.

3. That refrigerator makes things colder.

4. That iron ore is dug from beneath the earth's crust.

5. That our wet clothes get dry by a process known as evaporation.

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130 Douglas M. McIntosh, Statistics for the Teachers, Second Edition (London: Pergamon Press, 1967), p. 87.

6. That electrical energy can be converted to both light and heat energies.

7. That liquid water changes to steam at its boiling point.

8. That television needs electrical energy to function.

9. That tap water (i.e. purified) is safer to drink than raw well water.

10. That the moon's light is a reflection of the sun's light.

11. That rainbow is a result of the refraction of sun's rays through rain droplets.

12. That radio uses electrical energy.

13. That a working fan sets particles of air in motion.

14. That rain is formed from clouds.

15. That a magnet attracts magnetic substances such as iron nails and steel needles.

16. That rain water, unlike well water, does not contain dissolved solid substances.

The Piaget-like tasks of this study were designed to explore the cognitive thoughts of the subjects concerning the following concepts:

1. Conservation of distance.

2. Conservation of lengths.

3. Conservation of continuous quantity.

4. Conservation of discontinuous quantity.

5. Conservation of weight.

6. Height as a measurement between two reference points.
7. Displacement of water by a sinking object.
8. Distance-time relationship of speed.
9. Distance-speed relationship of time.
10. Weights of objects not necessarily a function of their sizes.

3.7 Sample and Sampling Procedure

The population of this study consists of elementary school pupils in primary classes four, five and six of public elementary schools (in Western State of Nigeria) which do not offer instruction in any aspect of physical science. This population falls within the age bracket of nine and twelve years since the official entry age into primary class one in the State is six years.

The sample of this study (a total of 979 subjects) was selected by randomization process as outlined below.

For purposes of efficient administration of public elementary schools in the State, elementary schools are grouped into four different zones according to their geographical locations. For convenience' sake, one of the four zones, called Osun/Ife/Ijesha Zone, was selected for this study; and Ife division[131] was selected from the three divisions that make up the Osun/Ife/Ijesha Zone.

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[131] The Osun/Ife/Ijesha zone is made up of three divisions, viz. Osun division, Ife division and Ijesha division.

A letter[132] requesting for a comprehensive list of elementary schools in the selected zone was addressed to the Principal Inspector of Education in the zone. In response to the letter, the investigator was furnished with a list of 941 public elementary schools and two private elementary schools in the zone on divisional basis. Out of the 941 public schools in the zone, the selected division boasts of 195 schools which are either triple, double or single-streamed[133] schools. As could be expected, most of the double-streamed schools and all the triple-streamed schools in the selected division are in Ife township with the rural environs having a preponderance of single-streamed schools, dotted with few scattered double-streamed schools. For the sake of uniformity, the investigator carried out this study only in single-streamed schools. A list of single-streamed schools in Ife township and its rural environs within a ten-mile radius was gleaned from the list of schools in the selected division. The gleaned list of schools [134] comprised fifteen schools which could be classified as urban schools and thirty-four schools which could be classified as non-urban schools according to the definitions of this study. These definitions are:

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[132] A copy of the letter and the reply to it are reproduced in Appendix X.

[133] For example, a single-streamed school has only one classroom per grade level, whereas a double-streamed school has two classrooms per grade level. The Education Law of the State prohibits a classroom in public elementary schools to seat more than 40 pupils.

[134] See Appendix XI for the list of screened, single-streamed schools.

(a) An urban area is a town which has:

(i) a population of 25, 000 or more,

(ii) electricity and pipe-borne water supply,

(iii) television services, and

(iv) public libraries.

(b) A non-urban area is a town characterized by the following:

(i) population of under 25, 000,

(ii) non-availability of electricity and pipe-borne water,

(iii) absence of television services, and

(iv) non-availability of a public library.

A random sample of six schools was then selected from the list of fifteen schools in Ife township by drawing their names one at a time, from a bag containing the names of the fifteen schools on different pieces of paper. A drawn name was put back into the bag after the name had been recorded before a fresh drawing was made. By this method, every school in the list of screened fifteen urban single-streamed schools had an equal chance of being drawn and, therefore, of being one of the schools in which the study was conducted. The same sampling procedure was used in selecting six schools from the list of thirty-four rural elementary schools. The twelve schools selected from the two categories of schools for the study are:

Urban

1. St. Bernard's RCM, Lagere, Ife
2. L. A. School, Ijesha, Bye-Page, Ife
3. St. Stephen's "B" Modakeke, Ife
4. St. Stephen's "C", Modakeke, Ife
5. Methodist School, Sabo, Ife
6. St. John's School, Ilare, Ife

Non-Urban

1. Coker Memorial School, Erefe
2. St. Paul's School, Iyanfoworogi
3. St. Paul's School, Alakowe
4. Methodist School, Oke-omi, Osu
5. Methodist School, Oke-oja, Osu
6. L. A. School, Ajebamidele

Permission to carry out the study in the selected schools was then sought from the respective headmasters of the schools.

A total of 979 subjects constituting a majority* of pupils in primary classes four, five and six of the twelve selected schools took part in this study. The breakdown of the 979 subjects according to class, sex, and geographical locations is contained in Tables 6 and 7 below.

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*Absenteeism and inability of some pupils to follow test directions accounted for the minority of pupils who were not covered by this study in the selected schools.

TABLE 6

URBAN SUBJECTS BY CLASS AND SEX

	Name of participating Urban schools	Primary class Six		Primary class Five		Primary class Four		Total
		Boys	Girls	Boys	Girls	Boys	Girls	
1.	St. Bernards, RCM, Ife	17	14	15	15	12	15	88
2.	Methodist School, Ife	22	10	10	13	19	16	90
3.	L. A. School, Ife	15	22	12	15	13	14	91
4.	St. Stephen's "B," Ife	24	12	16	13	15	10	90
5.	St. John's School, Ife	15	20	14	17	12	11	89
6.	St. Stephen's "C," Ife	15	14	13	15	9	11	77
	Total	108	92	80	88	80	77	525

TABLE 7

CLASSIFICATION OF NON—URBAN SUBJECTS BY CLASS AND SEX

	Names of participating Non-Urban schools	Primary class Six		Primary class Five		Primary class Four		Total
		Boys	Girls	Boys	Girls	Boys	Girls	
1.	Cocker Memorial School, Erefe	6	8	9	12	10	10	55
2.	L. A. School, Ajebamidele	11	10	12	12	13	8	66
3.	St. Paul's School, Iyanfowonogi	17	15	21	15	14	13	95
4.	St. Paul's School, Alakowe	13	12	18	9	7	9	68
5.	Methodist School, Oke-Omi	17	10	18	17	12	15	89
6.	Methodist School, Oke-Oja	17	16	14	15	9	10	81
	Total	81	71	92	80	65	65	454

3.8 Testing Procedure

This was a two-pronged exercise involving the administration of the two research instruments on the 979 subjects that made up the population sample for this study. First, the description of the administration of the physical science knowledge test, then the guide's.

The third draft of the test which was finally adopted for this study was administered to the subjects as a pencil-and-paper test by the investigator in their different classrooms. After necessary appointment and arrangements with the class teacher of a selected class, the investigator was formally introduced to the class. The pupils were then greeted cordially by the investigator and their cooperation solicited by saying that they were going to do a small job which they should not regard as an examination but as an exercise designed to discover what they knew about things around them. They were then given a detailed explanation of what they were expected to do before they were given copies of the test and the accompanying answer sheets.

Although the test booklet carried an explicit description of what should be done, the investigator always read the test directions to the pupils in order to be sure that they understood what they were expected to do. And in order to give the pupils an opportunity to practise the "circling out" of the appropriate letter in the answer sheet corresponding to the correct statement for an answer to a question, they were given the opportunity to work on the example below under the direction of the investigator:

My teacher is a:

(a) boy
(b) man
(c) girl
(d) woman.

While the answer was more often th. . not solicited from the class, the "circling out" of the correct letter in the answer sheet was in all cases carried out by class volunteers in the manner depicted below:

Answer sheet

1.	a	(b)	c	d
2.	a	b	c	d
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Before the pupils were asked to start working on the real test, they were allowed some time to raise any question that might clarify any doubt they might have on what they were expected to do, and it was after all the issues raised had been resolved that the pupils were asked to start working on the test.

Although the pupils were not given a time limit for the test, a period of thirty minutes was thought to be sufficient for the test. This was, however, discovered to be a very generous length of time to answer the sixteen items of the test as most of the subjects finished the test in no more than twenty minutes. Ho ·ver, the slower test-takers among them were not asked to stop writing and submit their papers at the expiration of the thirty minutes. The investigator just waited for the slower pupils to submit their test papers voluntarily. As it turned out, none of the 979 subjects of the study took more than forty minutes before turning in his or her test papers. It is important to note that the investigator was deliberately liberal with time because the test was not a speed test but something like a power test which was designed to discover what the subjects knew about the field covered by the test.

The Piaget-like tasks were carried out by all the 979 subjects of this study individually. Because of the large number of subjects involved and time factor, the investigator solicited the assistance of a graduate student in educational psychology in the Department of Education of University of Ife, Nigeria. The graduate student was then trained for the job he was to perform after he had indicated his willingness to take part in this portion of the study. The details of the research problems and philosophy were explained to him and he was taken through the interview guide for this portion of the study. But above all, as part of his training for the interview schedule, he watched the investigator, in two different sessions on two consecutive days, using the interview guide to elicit responses from more than twenty-five subjects. Subsequent interviews, mostly conducted under tree shades, were generally carried out with the graduate student acting as the second interviewer.

Like the physical science knowledge test, each subject was greeted familiarly and cordially when he appeared for the interview to allay any fear he might have about the interviewer and the tasks. He was assured that the interview was not an examination but a study of the activities which he would be called upon to perform. As a further familiarization scheme, the interviewer introduced himself to the subject and the subject was urged to introduce himself or herself, to state his or her sex (even though this was apparent to the interviewer) and to state his or her grade level (even though this was also known to the interviewer).

After all this preamble, the subject was then introduced to the activities of the guide with the interviewer giving directions and leading questions. The responses of the subject were then classified as correct or incorrect responses and the explanations given were classified reasonable, unreasonable or uncertain. In fact, this was mainly what was done by the interviewer with the exception of the fact that he was expected to jot down special explanations offered, whether they were reasonable or otherwise, in appropriate column in the answer sheet. It is significant to note that all verbal interactions with the individual subject was done in Yoruba. The mechanism of the interview is discussed in the following paragraphs using the first item of the interview guide reproduced below as an example.

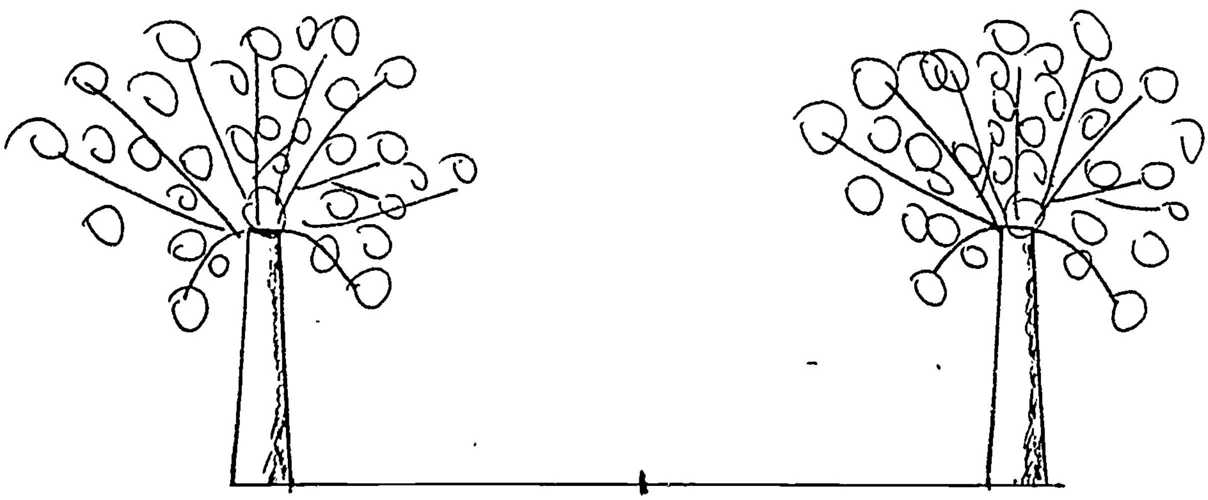
Item No. 1 of the Guide

Material: Two toy trees and a cardboard.

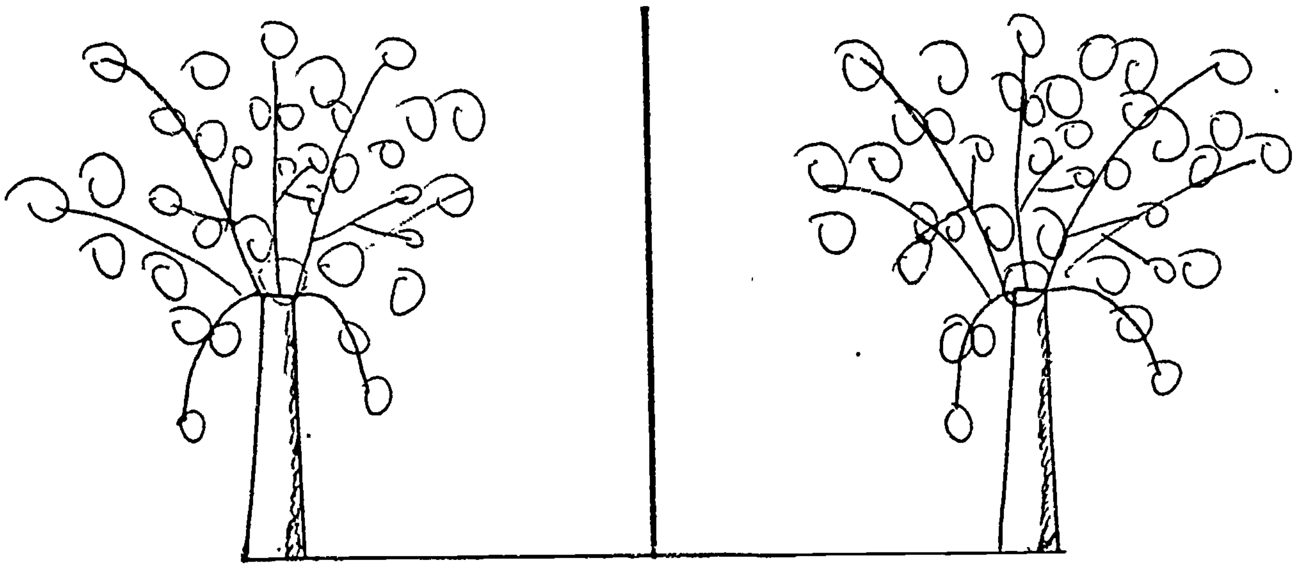
Direction: Call the attention of the subject to the fact that the two toy trees are separated by a known distance (say 12"). Ask him to place a tall cardboard midway between the two trees without displacing any of the toy trees.

Question: Has the distance between the trees changed or is it still the same? If the answer to the first part of the question is 'yes,' then ask whether they are closer or farther away from each other. Give reason(s) for your answer. If the answer to the second part of the question is 'yes,' ask the subject to give reason(s) for his response.

Each subject was asked to observe the two toy trees and to note in particular, the distance between the two toy trees. Diagrammatically, the set-up of this part of the activity looked like this:



The subject was then asked to place the tall cardboard midway (a marked position shown above) between the two toy trees. When the cardboard had been placed in the suggested position, the setup looked something like this:



The subject was asked whether the distance between the trees had changed or if it was still the same even with the cardboard standing between the trees. The response and the explanation offered by the subject was then entered immediately in the answer sheet, part of which is reproduced below for the response of an imaginary subject.

ANSWER SHEET

Item No.	Correct response	Incorrect response	Reasons given: Reason-able	Unrea-sonable	Un-certain	Special reasons offered
1		✓		✓		Longer distance: there are two distances now instead of one.

Finally, after a subject had been exposed to all the activities of the guide, he was warmly thanked for taking part in the study and then asked to go back to his classroom to invite the next subject for the interview.

3.9 Treatment of Data

The scores obtained by the subjects in the test and the tasks were subjected to appropriate inferential and non-inferential statistical analyses by the aid of the University of Ife Computer Centre. The types of analyses carried out on the scores were dictated by the nature of the six hypotheses of this study.

A brief discussion of the different types of analyses carried out in this study is contained below.

Hypothesis 1: It is hypothesized that the fourth, fifth and sixth graders in Western State of Nigeria possess a better-than-chance knowledge of incidental physical science knowledge.

Discussion of the Analysis carried out: On the basis of mere guess work alone, each subject of this study had a chance of scoring one fourth of the total possible score of sixteen because there were four alternatives to each of the sixteen items of the test. This gives a chance mean score of four for the entire sample of this study. A chance binomial model computation gave the standard deviation of this chance mean score of four as 1.73. These chance values were then constrated with the real mean score of 7.81 and standard deviation of 2.68 for the 979 subjects by t-test at 0.01 level of significance.

Hypothesis 2: It is hypothesized that there are differences in the nature of incidental physical science knowledge possessed by the fourth, fifth and sixth graders of this study.

Discussion of the Analysis carried out: The differences in the nature of incidental physical science knowledge possessed by the fourth, fifth and sixth graders of this study were studied by the examination of the frequency distribution profile of the responses of the pupils of the different grade levels to the test items. The scores of the subjects of the different grade levels were subjected to analysis of variance at 0.01 level to detect any differences in the amounts of incidental physical science knowledge possessed by the fourth, fifth and sixth graders of the study. Scheffe's test for multiple comparison was then applied.

Hypothesis 3: It is hypothesized that there are differences in the nature and the amounts of incidental physical science knowledge possessed by school children in the urban and non-urban areas of Western State of Nigeria.

Discussion of the Analysis carried out: Frequency distribution profile was also used in assessing the differences in the nature of incidental physical science knowledge possessed by school children in the urban and non-urban areas while a t-test at 0.01 level was employed in the determination of the differences between the amounts of incidental physical science knowledge possessed by the two groups.

Hypothesis 4: It is hypothesized that there are differences in the performances of fourth, fifth and sixth graders on Piaget-like tasks.

Discussion of the Analysis carried out: Simple analysis of variance at 0.01 level was utilized to detect any difference in the performances of the fourth, fifth and sixth graders in the Piaget-like tasks. Scheffe's test for multiple comparison was then applied.

Hypothesis 5: It is hypothesized that there is some difference in the performances of school children in the urban and non-urban areas of Western State of Nigeria on Piaget-like tasks.

Discussion of the Analysis carried out: A t-test analysis was carried out on the rated performances of the two categories of school children.

Hypothesis 6: It is hypothesized that there is a positive correlation between the amount of incidental physical science knowledge possessed by school children of each grade of study and their performance on Piaget-like tasks.

Discussion of the Analysis carried out: A product-moment correlation analysis was carried out on the pair of scores of pupils in each grade studied. The significance of the correlation coefficients obtained was determined at 0.05 level by the use of statistical tables.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter discusses, among other things, an item-by-item analysis of the sample's responses to the two research instruments, the results of the various statistical analyses which the subjects' responses were subjected to and the significance of the hypotheses of this study in the light of both the empirical and statistical results.

4.1 Item-by-Item Analysis of the Sample's Responses to the Research Instruments

Before discussing the various results of this study as they relate to the hypotheses, it is pertinent at this point to first of all discuss the overall performances of the entire sample of this study on the research instruments. The discussion that follows, therefore, focuses attention on the performances of the entire sample.

An item-by-item analysis of the responses of the subjects of this study to the multiple-choice, sixteen-item science knowledge test revealed some striking results. For example, while only 16.8 percent of the entire 979 subjects responded that "rain is formed from clouds," as many as 46.5 percent of them thought that "rain is formed from God" and 12.1 percent of them indicated that "rain is formed from 'Sango,'" the traditional Yoruba god of thunder and lightning. The test-item in question is item 14 of the science knowledge test. But before delving more into the different ramifications of the "life responses" of the subjects to the test-items, it is relevant at this juncture to present a summary of their responses (choices) to each of the multiple-choice, sixteen test-items on percentage basis. This summary is contained in the table below.

TABLE 8

THE CHOICES OF THE ENTIRE SAMPLE ON THE MULTIPLE-CHOICE SCIENCE KNOWLEDGE TEST ON PERCENTAGE BASIS:

No.	"a" choice	"b" choice	"d" choice	"e" choice	% Omissions	Correct letter-choice*
1	77.6	8.80	4.50	1,94	7.16	a
2	10.1	78.0	1.33	2.16	8.41	b
3	13.4	10.1	60.5	3.99	12.0	d
4	13.6	24.2	10.5	40.1	11.6	e
5	21.1	12.6	46.0	8.80	11.5	d
6	14.5	15.6	40.2	15.3	14.4	d
7	51.6	24.2	10.1	6.33	7.77	a
8	12.9	14.8	38.2	20.0	14.1	d
9	28.8	7.15	7.55	42.6	14.7	e
10	34.0	30.8	11.0	9.70	14.5	b
11	28.6	19.8	21.2	9.72	20.2	d
12	38.4	31.0	6.95	9.70	14.0	b
13	20.2	47.2	9.20	6.23	17.2	b
14	46.5	12.1	16.8	10.3	14.3	d
15	40.6	24.4	10.3	10.8	13.9	b
16	25.4	32.2	7.86	26.2	8.34	a

With reference to above table and the final science knowledge test contained in Appendix IV, the following observations and comments

*The "a, b, d, and e" letter-choices are according to the first four letters of the Yoruba alphabet.

about the item-by-item analysis of the responses of the entire sample of this study are pertinent at this point.

1. As could be seen from above table, a large percentage (77.6%) of the sample of this study know that "telephone can be used to talk to our friends."

2. Seventy-eight percent of the subjects are aware of the fact that "the chief source of light in the day in Nigeria is the sun."

3. A total of 60.5 percent of the respondents indicate that "a refrigerator is used to make things (e.g. Coca-cola drink) colder." It is significant to note that the preponderance of subjects who do not possess the knowledge concerning the refrigeration ability of refrigerators comes from the rural areas of the state with only 51.0 percent of them (the rural subjects) giving correct response to this item.

4. Less than half of the entire sample know that "iron [ore] is obtained from [beneath] the earth's crust."

5. Only 46.0 percent of the subjects know that "our wet clothes on the line get dry due to evaporation."

6. That "electricity can produce [both] light and heat," is the choice of only 40.2 percent of the entire sample. Again, the large percentage of subjects who did very poorly in this item come from the non-urban area of the State. (Only 33.6 percent of the non-urban subjects got this item correct.)

7. Barely 50 percent of the sample know that "when water is boiling some of it turns to steam." This poor result is rather surpris-

ing because most children in Nigeria help their parents with everyday domestic chores which, of course, include boiling water. It might, therefore, be anticipated that a large percentage of the subjects might have ample occasions in observing part of boiling water being converted to steam. Why then did they perform very poorly on the item? Could this be due to poor observations on the part of the subjects? Whatever be the case, one thing is sure. This finding has sericus implications for science curriculum in the State.

8. That "television uses electricity" is the choice of only 38.2 percent of the sample for item 8. But as many as 20 percent of them "confused" what television uses with what it produces by choosing "sound" for the answer to: "television uses..."

9. That "tap water is good for our health because it is cleaner than well water" is the choice of over 42 percent of the subjects.

10. Only 30.8 percent of the subjects know that "moon gets its light energy from the sun," while as many as 34 percent of them think that moon possesses its own light energy. It should, however, be stated in passing that the answer to this item is outside the direct observable experiential domain of the child. To know the answer to this item, a child has to have heard about the subject somewhere or read about it some place.

11. While only 21.2 percent of the sample indicate that "rainbow is caused by the [incidence of] rays of the sun on rain [droplets]," a greater percentage (28.6%) of the subjects think that rainbow is caused

by "the god of rain" and as many as 19.8 percent of them say that "rainbow is caused by the 'evil wish of witches.'" It is important to note that the wrong responses of the subjects have grave implications for science education in the State, because it is very obvious that the responses of most of the subjects to this item are beclouded by the traditional beliefs about rainbow among the Yorubas of Western State of Nigeria. It is relevant at this juncture to introduce the reader to other "superstitious" beliefs about rainbow among Yorubas. These include: That the occurrence of rainbow is a sign that (a) "a leopard is giving birth," (b) a python is giving birth near a river," and (c) "an important man is dead or is going to die in the near future." These beliefs about rainbow among Yorubas, of course, have their roots in the traditional Yoruba mythology and the animist religion of the people.

12. In this item, as in item 8 dealing with television, many subjects "confused" what an electrical gadget "consumes" with what it "does or produces," in that only 31 percent of them say that "a radio uses electricity," whereas as many as 38.4 percent indicate that "a radio uses sound." And, needless to say, there is a striking difference between the correct responses of the urban and non-urban subjects in favour of urban subjects. In fact, only 20 percent of the non-urban subjects as against over 40 percent of the urban subjects scored the item correctly. Again, the curriculum implications of the findings are very obvious.

13. Over 47 percent of the sample know that "a working fan causes air t move fast." This item does not result in a striking difference between the responses of the urban and the non-urban subjects because the use of hand-made fans, of course not electrical fans, is common to both the two sub-cultures within the Yoruba culture.

14. This is an item which deals with rain formation— an aspect of natural phenomena which is rooted in the religious and cultural beliefs of the subjects. While only 16.8 percent of the subjects know that "rain is formed from clouds," as many as 46.5 percent of them believe that "rain is formed from God." Another 12.1 percent of them indicate that "rain is formed from [better read, by] Sango," the god of thunder and lightning according to Yoruba mythology. It is needless to say there is a serious curriculum implication for this finding.

15. Over 40 percent of the subjects think that "a piece of metal or stone which picks up nails, needles and pins is a hammer," whereas only 24 percent of them know that such "a piece of metal or stone" is called a "magnet." While it is possible that a large percentage of the children tested might have never seen a magnet in their life, let alone know what it does, it is quite probable that many of them might have observed carpenters at work using "double-purpose" hammers to remove nails from wooden frames. So a confusion as to what a carpenter uses a hammer for might have led as many as 40.6 percent of the subjects to wrongly construe a hammer as a piece of metal that "picks up" nails.

16. Like items 11 and 14, the responses of the majority of the subjects to item 16 is closely linked with their religious beliefs. As many as 32.2 percent of the sample believe that "rain water is purer than water from the well because rain water comes from heaven," whereas only 25.4 percent of them know that "rain water is purer... because rain water does not contain dissolved solid substances," which abound in raw well water. Another significant response of the subjects worthy of attention is "that rain water is purer...because rain water comes from God." Over 26 percent of the subjects believe that response to be correct. The subjects' wrong responses to item 16 are yet another example of the consequences of the religious background or animist beliefs of the subjects.

Like the science knowledge test, an item-by-item analysis of the responses of the entire subjects to the items of the interview guide for Piaget-like tasks was carried out. The outcome of the item analysis is best illustrated by a summary of the performances of the subjects on Piaget-like tasks and some discussion of some of the "life responses" of the subjects. The table below summarizes the performances, on percentage basis, of the 979 subjects whose ages ranged between nine and eleven years.

TABLE 9

PERFORMANCES OF THE ENTIRE SAMPLE ON PIAGET - LIKE TASKS - ON PERCENTAGE BASIS

Item No.	Description of Tasks	Percentage of students giving correct response to the Tasks N = 979
1	Conservation of Distance	24.2
2	Conservation of Lengths	32.0
3	Conservation of Continuous Quantity	94.8
4	Conservation of Discontinuous Quantity	68.0
5	Conservation of Weight	70.1
6	Concept of Height	86.1
7	Concept of Displacement	97.5
8	Concept of Speed	70.5
9	Concept of Time	63.8
10	Concept of Relative Weight	96.0

With reference to above table and the third draft of the interview guide in Appendix VI, the following observations are offered on item-by-item basis.

1. To the task dealing with conservation of distance between two toy trees in the presence of an interposed cardboard, only 24.2 percent of the entire sample knew that the distance between the two trees remains unchanged by merely placing a cardboard between the

trees. Of the rest of the sample who denied conservation, most responded that there was a gain in the distance between the trees because "there are now two distinct spaces." To these children, the sum of parts of a whole is greater than the whole itself. A minority of the "non-conservers" of distance thought that there is a decrease in the distance between the trees on introducing the cardboard because "the cardboard takes up some space." In a sense, this response seems plausible. But such respondents were designated "non-conservers" of distance because they failed to realise that the addition of the two spaces created by the cardboard and the space occupied by the edge of the cardboard add up to the original distance between the two trees. It is significant to know that while all the subjects tested agreed that the distance between the trees remained the same after the cardboard had been removed, the "non-conservers" failed to see the inconsistency in their responses.

2. The second activity of the Piaget-like tasks presented as much difficulty as the first task to many of the subjects. When one of the two identical match sticks lying parallel, edge to edge to each other was pushed slightly to one side, only 32 percent of the sample realized that the lengths of the two match sticks were still equal despite the lateral transformation of one of them. A large majority of the subjects thought that the displaced match stick was longer than the second match stick because "it shoots out in this end," with most of the subjects pointing in the direction of the displacement.

This response is probably due to the fact that the "non-conservers" were unable to focus their attention on two dimensions simultaneously in order to discover that when the displaced match stick "shoots out on this side," the other match "shoots out on the other side." Thus, the lateral displacement on one side is compensated for by lateral displacement on the other side resulting in conservation of lengths. And like the first task, while all the subjects agreed that the lengths of the two match sticks were equal when they were placed edge to edge again, the "non-conservers" failed to discover the incongruity of their statements.

3. The sample performed very well in the task concerning pouring water from one of two similar vessels containing equal amounts of water into a tall narrow dissimilar container with the second similar vessel standing as a standard. As many as 94.8 percent of the entire sample were able to buttress their statements about the equality of the amounts of water in the two vessels containing water after the transfer with rational explanations such as "since no water was allowed to drop during pouring or since nothing is added or subtracted from the quantities of water," equality must hold. The few who missed the item thought that the taller vessel contained more water than the standard vessel because "the water column in the tall glass is higher than that in the standard glass." The "non-conservers" of quantity in this instance also failed to discover inconsistency in their statements when they agreed to the equality of amounts of water in the

two similar vessels having poured back the water in the tall narrow vessel to its original container.

4. When the subjects were asked to powder up one of two equal pieces of chalk, 68 percent of them asserted that the powdered chalk contained as much chalk as the unpowdered chalk with necessary rational explanation. The rest of the subjects either said that the "powdered chalk" contained less chalk because it is [looks] smaller than the unpowdered chalk" or that it "contains more chalk because it is powdered [meaning, it has more grains]."

5. About 70.1 percent of the subjects "believed" in conservation of weight examplified by the comparison of the weight of two halves of a plasticine ball with an identical uncut ball. While a majority of the rest of the sample thought that "the two pieces from the cut ball weigh more than the uncut reference ball because two units are heavier than one," a minority of them was of the opinion that "the uncut ball is heavier than the two pieces together because it is [looks] bulkier than the pieces."

6. In the activity calling on the children to build a tower (with wooden cubes) which should be equal in height to one already built by the investigator on a higher table or an elevated surface, 86.1 percent of them were able to correctly construct models of the tower on a table or a surface which is two wooden cubes height lower than the surface on which the reference tower was constructed by the investigator. And when queried about the equality of the heights of the two

towers in the face of an apparent difference in the heights of the towers, they indicated that the two towers were equal in height because "they are built of an equal number of identical wooden cubes and that the apparent difference in their heights is due to differences in their bases." The few who missed this item constructed towers which took two more building cubes in order to equalize the apparent heights of the two towers. However, most of these subjects were surprised to find that their towers were actually taller than the investigator's tower when the bases of their towers and the investigator's were equalized.

7. Almost all the subjects (97.5% of them) were able to predict a rise in water level caused by the introduction of a piece of stone into a vessel containing water. And when the experiment was performed, they asserted that the displacement of water was due to the fact that "some water was displaced by the stone occupying the space originally occupied by the displaced water." Although most of the rest of the subjects were able to predict the rise in water level due to the introduction of a stone, they thought that the displacement of the water was due to the "weight and not the volume" of the stone.

8. When two toy cars which started their journeys from different origins at the same time raced across a table reaching the same destination at the same time, 70.5 percent of the subjects rationalized this observation by saying that "the cars travel at unequal speeds" with the one which travels a greater distance or the one at the rear before they started their journeys having "greater speed." Some

of the rest of the subjects.when queried about the relative speeds of the cars thought that "the speeds of the cars are equal since they start and stop at the same time," while others thought that the slower car is really faster because "it was in front at the beginning of the race."

9. With two dolls racing across the table from a common origin but reaching different destinations in equal time, 63.8 percent of the subjects asserted that "the time taken by the dolls is equal even though they covered different distances." Equality of time was established by the subjects by the following command: "Start, 1, 2, 3, 4, Stop," while the experiment was in progress. Most of the subjects who provided irrational explanations for this task thought that the slower doll took more time for its journey because "it would need more time to catch up with the other doll."

10. This activity deals with the relative weights of two objects in which the smaller one weighed more than the bigger one because of the presence of embedded lead shots in the small one. As many as 96 percent of the subjects were able to detect that the smaller object was heavier because "it feels heavier to the hand." The rest of the subjects picked the bigger object as the heavier object apparently because of its "size." And further queries revealed that the children have difficulty in distinguishing between size and weight in that they persistently asserted that "the bigger ball is heavier because it is bigger."

4.2 Raw Scores

The paired raw scores for each subject of the entire population sample of 979 subjects on the physical science knowledge test and the Piaget-like tasks are tabulated in Appendix XV according to geographical location, sex and class. A careful examination of the scores would show that urban pupils performed better in general than their non-urban counterparts in both the physical science knowledge test and the Piaget-like tasks, and would also reveal that there was, to some extent, a direct relationship between class level and level of performance on the tests. That is, primary class six pupils showed superior performance in general over primary class five pupils who, in turn, were better performers in general on the tests than primary class four pupils.

4.3 Means and Standard Deviations

In anticipation of pertinent inferential statistical analyses, means and standard deviations of different shades of the sample were computed for each of the two research instruments. Tables 10, 11 and 12 below give the summaries of the results of the computational exercise on the raw scores of the subjects on the physical science knowledge test.

TABLE 10

MEANS AND STANDARD DEVIATIONS
OF THE ENTIRE, URBAN AND NON-URBAN SAMPLES ON THE
PHYSICAL SCIENCE KNOWLEDGE TEST

	SAMPLE DESCRIPTION		
	Entire Sample	Urban Sample	Non-urban Sample
Sample Size	979	525	454
Means	7.81	8.55	6.96
Standard Deviations	2.68	2.68	2.42

TABLE 11

MEANS AND STANDARD DEVIATIONS OF THE URBAN SAMPLE ON
THE PHYSICAL SCIENCE KNOWLEDGE TEST ACCORDING TO
CLASS AND SEX

	SAMPLE DESCRIPTION					
	Primary Class VI		Primary Class V		Primary Class IV	
	Male	Female	Male	Female	Male	Female
Sample Size	108	92	80	88	80	77
Means	10.6	9.96	7.97	7.90	7.19	6.73
Standard Deviations	2.19	2.04	2.28	2.61	2.08	2.25

TABLE 12

MEANS AND STANDARD DEVIATIONS OF THE NON-URBAN SAMPLE ON THE PHYSICAL SCIENCE KNOWLEDGE TEST ACCORDING TO CLASS AND SEX

	SAMPLE DESCRIPTION					
	Primary Class VI		Primary Class V		Primary Class IV	
	Male	Female	Male	Female	Male	Female
Sample Size	81	71	92	80	65	65
Means	6.68	7.80	6.68	6.70	5.80	5.75
Standard Deviations	2.11	2.14	2.35	2.28	1.99	2.25

As could be seen above (Table 10), urban pupils performed better on the physical science knowledge test than their non-urban counterparts in that the mean score of the urban sample was 8.55, while that of the non-urban sample was only 6.96. It is significant to note that the entire sample had a mean score of 7.81, a much higher score than a mean score of 4.00 which could have resulted from mere guess by the sample for the answers to the multiple choice test.

Table 11 gives a breakdown of the mean scores of the subjects according to sex and class. A close study of this breakdown would show that male subjects of this study performed better than their female counterparts in general; and there seemed to be a positive correlation between class level and the level of performance in that the higher class pupils had a superior mean score over the lower class pupils. The same trend is repeated in Table 12 dealing with the non-urban sample of this study.

The means and standard deviations for different shades of the sample were also calculated for the correct responses of the sample to the Piaget-like tasks. The following tables summarise the results of the exercise.

TABLE 13

MEANS AND STANDARD DEVIATIONS OF THE ENTIRE, URBAN AND NON-URBAN SAMPLES ON THE PIAGET-LIKE TASKS

	SAMPLE DESCRIPTION		
	Entire Sample	Urban Sample	Non-urban Sample
Sample Size	979	525	454
Means	6.74	6.92	6.54
Standard Deviations	1.67	1.68	1.65

TABLE 14

MEANS AND STANDARD DEVIATIONS OF THE URBAN SAMPLE ON THE PIAGET-LIKE TASKS ACCORDING TO CLASS AND SEX

	SAMPLE DESCRIPTION					
	Primary Class VI		Primary Class V		Primary Class IV	
	Male	Female	Male	Female	Male	Female
Sample Size	108	92	80	88	80	77
Means	7.16	7.18	6.59	7.11	6.54	6.77
Standard Deviations	1.69	1.66	1.65	1.73	1.65	1.52

TABLE 15

MEANS AND STANDARD DEVIATIONS OF NON-URBAN SAMPLE ON THE PIAGET-LIKE TASKS ACCORDING TO CLASS AND SEX

	SAMPLE DESCRIPTION					
	Primary Class VI		Primary Class V		Primary Class IV	
	Male	Female	Male	Female	Male	Female
Sample Size	81	71	92	80	65	65
Means	6.83	7.06	6.60	6.29	6.23	6.12
Standard Deviations	1.76	1.82	1.39	1.35	1.70	1.72

As in the analysis of the physical science knowledge test results, the urban sample of this study appeared superior to their non-urban counterparts in their performance on the Piaget-like tasks as shown in Table 13. They averaged 6.92 against 6.54 for their non-urban counterparts in their correct responses to questions dealing with Piaget-like tasks of this study. A further breakdown of the performances of the sample as shown in Tables 14 and 15 showed that class level was an important factor on the level of performance of the sample on the Piaget-like tasks.

4.4 t-tests

Analyses of t-tests were carried out on three pairs of means of the different shades of the sample to deduce the statistical significance, if any, of the difference between each pair of means. In particular, these analyses involved the application of the t-test on the following: (1) the mean score of the entire sample on the physical science knowledge test against the chance mean score of the sample on the test, (2) the mean score of the urban sample versus that of the non-urban sample on the physical science knowledge test, and (3) the pair of mean scores of both urban and non-urban samples on the Piaget-like tasks. The outcome of the analyses is summarized below in Tables 16 and 17.

TABLE 16

RESULTS OF T-TEST ANALYSIS OF THE DIFFERENCE BETWEEN THE MEAN SCORES OF THE SAMPLES ON THE PHYSICAL SCIENCE KNOWLEDGE TEST

Sample Description	Sample Size	Means	Standard Deviations	Computed t-values
Entire Sample	979	7.81	2.68	37.4
Imaginary Sample	979	4.00	1.73	
Urban Sample	525	8.55	2.68	9.77
Non-urban Sample	454	6.96	2.42	

TABLE 17

RESULTS OF T-TEST ANALYSIS OF THE DIFFERENCE BETWEEN THE MEAN SCORES OF THE SAMPLES ON THE PIAGET-LIKE TASKS

Sample Description	Sample Size	Means	Standard Deviations	Computed t-values
Urban Sample	525	6.92	1.68	3.58
Non-urban Sample	454	6.54	1.65	

4.5 Analysis of Variance

Two separate analyses of variance were carried out: One on the scores of the subjects on the physical science knowledge test according to class and the other on their scores on the Piaget-like tasks also according to class. These analyses were carried out to detect significant differences, if any, in the performances of the subjects on the two instruments according to their classes. The two tables below give the summaries of the computational exercise carried out.

TABLE 18

SUMMARY OF THE ANALYSIS OF VARIANCE OF THE SCORES OF PRIMARY CLASSES SIX, FIVE AND FOUR PUPILS OF THIS STUDY IN THE PHYSICAL SCIENCE KNOWLEDGE TEST

Source of Variation	Sum of Squares (SS)	Degree of Freedom (df)	Mean Square (MS)	Calculated F-ratio
between groups	890.88	2	445.44	11.2
within groups	38108.40	976	39.96	
Total	38999.28	978		

TABLE 19

SUMMARY OF THE ANALYSIS OF VARIANCE OF THE SCORES OF PRIMARY CLASSES SIX, FIVE AND FOUR PUPILS OF THIS STUDY ON THE PIAGET-LIKE TASKS

Source of Variation	Sum of Squares (SS)	Degree of Freedom (df)	Mean Square (MS)	Calculated F-ratio
between groups	81.83	2	40.91	1.25
within groups	31923.10	976	32.71	
Total	32004.93	978		

4.6 Correlation Coefficients

In order to discover whether there is positive correlation between the achievements of the subjects on the physical science knowledge test and their performances on the Piaget-like tasks, product moment correlation coefficient was computed for each grade level from the set of pair of scores obtained by each of the subjects in the two instruments. Table 20 gives the summary of the correlational analyses.

TABLE 20

SUMMARY OF CORRELATIONAL ANALYSES OF THE SCORES OF THE SAMPLE ON BOTH THE PHYSICAL SCIENCE KNOWLEDGE AND THE PIAGET-LIKE TASKS

Description of Data Analysis	Primary Class VI	Primary Class V	Primary Class IV
Sum of scores of the subjects on the test: ΣX	3320.0	2484.00	1844.00
Sum of scores on the subjects on the tasks: ΣY	2488.00	2263.00	1855.00
Sum of product of XY values: ΣXY	23556.00	16728.00	12085.00
Sum of squares of X: ΣX^2	33310.00	20222.00	13256.00
Sum of squares of Y: ΣY^2	18636.00	15897.00	12745.00
Computed correlation coefficient	0.0620	0.150	0.160
Sample Size	352	340	287

4.7 Testing the Hypotheses of this Study

All in all, six hypotheses were subjected to statistical tests in this study. The discussion that follows deals with the results of the statistical analyses.

Hypothesis 1: That the fourth, fifth and sixth graders in Western State of Nigeria possess a better-than-chance knowledge of incidental physical science knowledge.

The above hypothesis was tested by applying t-test on the mean score of the 979 subjects on the physical science knowledge test and their "chance mean score" to determine any significant difference between these mean scores. By mere guess alone, the sample of this study was expected to have a mean score of four on the four-choice sixteen-item science test; and a chance binomial model (variance = n x p x q)* gave a standard deviation of 1.73 for the chance mean score of four. The table below gives the summary of data necessary for testing the acceptability of above hypothesis.

TABLE 21

DATA FOR COMPUTING T-VALUE FOR TESTING HYPOTHESIS I

Sample Description	Sample Size	Mean Score	Standard Deviation	Computed t-value
"Real" Population Sample	979	7.81	2.68	37.4
"Imaginary" Population Sample	979	4.00	1.73	

*Where "n" is the number of test items, "p" is the probability of success and "q" is the probability of failure.

The t-value of 37.4 was found to be statistically significant at 0.01 level (t_t = 2.58 at 0.01 level, df = ∞; t_c = 37.4, df = 1956). A confidence interval was then computed for the population mean's difference. It was found that the difference between the population means lay between 3.55 and 4.07 ($3.55 < M_1 - M_2 < 4.07$). As this difference between the population means does not include zero, it may be asserted that there is 99% confidence that the tested hypothesis is true. Therefore, the hypothesis that the fourth, fifth and sixth graders in Western State of Nigeria possess a better-than-chance knowledge of incidental physical science knowledge is statistically upheld.

Discussion: The implication of above result and conclusion is not far-fetched at all. The idea of incidental learnings is further reinforced by the above revelation. After all, Nigerian children like their counterparts anywhere in the world, do not live in a social vacuum but in a cultural environment full of interactions with other members of their society. These interactions coupled with children's personal observations and other non-school experiences might have resulted in the incidental science knowledge possessed by the children.

While nobody would deny the important role incidental learnings could play in the life of a child, the onus of making commonly observable environmental elements to form the foundation and possibly the springboard of an enriching curriculum lies on the curriculum expert and interested educators as well. It is left to curriculum designers in the State to find the best way of "injecting" some of the concepts covered by the physical science knowledge test of this study into the elementary school curriculum of the State.

Hypothesis 2: That there are differences in the nature and the amounts of incidental physical science knowledge possessed by the fourth, fifth and sixth graders of this study.

In order to detect the differences, if any, in the nature of incidental physical science knowledge possessed by the pupils in the different grades of this study, the frequency distribution profile of scores of the entire subjects on the science test in appendix XVI was subjected to a closer study. And for the sake of convenience in discussing the observed differences, a pertinent extract was culled from the frequency distribution profile of the entire sample. This extract reproduced below in Table 22 dealt only with test-items in which less than 25% of the entire subjects got correct.

TABLE 22

EXTRACT FROM FREQUENCY DISTRIBUTION PROFILE OF SAMPLE'S CHOICES ON THE PHYSICAL SCIENCE KNOWLEDGE TEST: QUESTION ITEMS IN WHICH LESS THAN 25% OF THE SUBJECTS CHOSE THE CORRECT ALTERNATIVE

Geographical Locations	Primary Class Six				Primary Class Five				Primary Class Four			
	Male		Female		Male		Female		Male		Female	
	Item No.	%	Item No.	%	Item No.	%	Item No.	%	Item No.	%	Item No.	%
URBAN	11	23.2	11	21.6	14	15.2	15	18.2	10	18.9	4	21.6
			14	13.0	15	20.0	16	21.6	11	16.2	10	13.8
			15	19.6					14	8.8	11	17.7
									15	15.2	15	11.6
									16	16.2	16	17.7
NON-URBAN	10	24.6	12	24.0	6	23.8	11	18.9	6	24.6	10	23.1
	11	19.8	14	24.0	8	17.4	14	16.2	8	9.2	11	13.9
	14	16.0	16	21.0	11	22.8	15	18.9	9	15.4	14	18.4
					12	13.0			10	23.1		
					14	10.8			11	15.4		
					16	23.8			12	20.0		
									14	6.2		
									15	16.9		
									16	16.9		

As could easily be deduced from above table, any noticeable differences according to class could only be observed between primary class four pupils and the pupils of the other two classes in reference to test items 4, 8 and 9. Item 4 dealt with the occurrence of iron, item 8 with what television uses and item 9 with the reason why tap water is safer to drink than well water.

Discussion: The only reason that can be advanced for this apparent difference is that the fourth graders are not as knowledgeable as their "big brothers and sisters" in the upper classes in the area covered by the test. In fact, their performance in general bears testimony to this fact.

The statistical significance of the amounts of incidental physical science knowledge possessed by the pupils in the three different grades of this study was tested by the application of analysis of variance on the raw-scores of the samples of the different grades. The summary of the results of this analysis is contained in Table 18 above. As could be seen from the table, the computed F-ratio is 11.2 with two as the degree of freedom for "between groups" and 976 for "within groups." This F-ratio of 11.2 was found to be statistically significant at 0.01 level when compared with the tabled F-values ($F_t = 4.61$; df = $2,\infty$).

A further statistical analysis was carried out to determine where the significant difference(s) lay: By comparing the population means of the sixth and fifth graders, and those of the sixth and fourth and finally contrasting the population mean of the fifth graders with that of the fourth graders with the use of Scheffe's analysis. For the sixth and fifth graders, it was found that the difference between their population means lay between 0.510 and 3.41 (i.e. $0.510 < M_1 - M_2 < 3.41$) at 99% confidence level. The comparison between the population means of the sixth and fourth graders yielded also a non-zero interval of $0.380 < M_1 - M_3 < 4.42$ at 99% confidence level. But unlike the above comparisons, the population mean difference between the fifth and the fourth graders lay within an interval which included zero. The details are: $-0.590 < M_2 - M_3 < 2.47$.

On the basis of above results, it could be asserted with 99% confidence that: (1) The amount of incidental physical science knowledge possessed by sixth graders in Western State of Nigeria is statistically superior to the amount possessed by fifth graders, and (2) the amount of incidental physical science knowledge possessed by sixth graders in the State is also statistically superior to the amount possessed by fourth graders. This conclusion is probably not totally unexpected since the sixth graders should, all things being equal, have more knowledge and experience about their environment than both the fifth and fourth graders.

The statistical analysis of the difference between the population means of the fifth and fourth graders produces an interval which includes zero (an interval between -0.590 and 2.47). This means that the difference between these population means could be anything between -0.590 and 2.47 including zero. On the basis of this revelation, there is no way of knowing whether there exists a non-zero difference between the population means of the fifth and fourth graders. However, one thing is certain: The fifth graders of this study scored higher on the test than the fourth graders as shown in Table 23 below:

TABLE 23

MEANS AND STANDARD DEVIATIONS OF THE ENTIRE SAMPLE ON THE PHYSICAL SCIENCE KNOWLEDGE TEST ACCORDING TO CLASS

	Primary Class Six	Primary Class Five	Primary Class Four
Sample Size	352	340	287
Means	9.27	7.31	6.37
Standard Deviations	2.34	2.45	2.28

Hypothesis 3: That there are differences in the nature and the amounts of incidental physical science knowledge possessed by school children in the urban and non-urban areas of Western State of Nigeria.

The differences in the nature of incidental physical science knowledge possessed by school children in the urban and non-urban areas of the State could be studied by focusing attention on items 6, 8, 9 and 12 of the test (see Table 22 above). It should be noted in passing that non-urban subjects did very poorly in these items in contrast to their urban counterparts. And it is pertinent at this juncture to discuss the content of those items. Item 6 dealt with electricity, its ability to produce both light and heat; item 8 dealt with the fact that television uses electricity; and item 9 was concerned with tap water while item 12 queried the subjects on the source of energy for radios.

Discussion: The poor performance of the non-urban subjects in the items identified above is not surprising at all knowing fully well that non-urban areas of Western State of Nigeria are deprived of modern utilities such as electricity and tap water. A direct consequence of this is that the non-urban child might not even be aware of what electricity and tap water are, let alone what their usefulness or importance is. Paradoxically, he might be hearing of electricity, television and radio for the firs time in his life when he was taking the science test for this study. This boils down to the fact that the non-urban child in the State is handicapped by circumstances beyond his control. This observation is shared by an earlier researcher, in both the urban and non-urban areas of the State, who asserted that:

> Apart from the socio-economic aspect of the case [between the urban and non-urban children] the city provides more varying and fruitful experiences which are conducive to both formal and informal education. Newspapers and magazines are readily available to the city pupils even when their parents do not buy them. There are different kinds of bill boards all over the streets....[135]

It is important to note that the difference between the urban and non-urban pupils in the State does not end with the nature of incidental physical science knowledge they possess but that it is also observable

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[135] Isaac Balogun, "The Intellectual and Residential Correlates of Reading Achievement in Nigerian Secondary Schools." (Unpublished dissertation, N.Y.U., 1972), p. 72.

in the amount of incidental science knowledge they possess. For example, the urban pupils had a mean score of 8.55 while their non-urban counterparts could only boast of a mean score of 6.96 (see Table 16 above). A t-test analysis on the difference between these means yielded a t-value of 9.77 which was found to be statistically significant at 0.01 level ($t_t = 2.58$). And the confidence interval computed for the difference between the population means was found to lie between 1.43 and 1.75 (i.e., $1.43 < M_1 - M_2 < 1.75$) at 99% confidence level. Since the computed interval does not include zero, the investigator is 99% confident that there is a significant difference between the amounts of incidental physical science knowledge possessed by both urban and non-urban pupils in the State in favour of the urban pupils. This difference is yet another revelation about the disparity in basic amenities between the urban and non-urban areas of the State; and the investigator sees the government of the State as the only potent body to rectify this disparity. How soon this could be done is a question the investigator cannot find an answer for. But it may suffice at the present time to warn curriculum developers in the State about the existence of a situation in the non-urban areas of the State which is not conducive to incidental learning.

Hypothesis 4: That there is a difference in the performances of fourth, fifth and sixth graders on Piaget-like tasks.

To establish whether there is a significant difference in the performances of fourth, fifth and sixth graders of this study on the Piaget-like tasks, the rated responses of the pupils to queries on the tasks were subjected to analysis of variance. The summary of the results of this analysis contained in Table 19 showed that the computed F-ratio for the analysis is 1.25 (df = 2, 978). This F-ratio of 1.25 was then compared with the corresponding tabled F-ratio (4.61) for 99% confidence level. As the computed F-value is smaller than the tabled F-value, there is no way of knowing whether there is a "real" difference in the performances of the fourth, fifth and sixth graders on the Piaget-like tasks. Another way of putting the above statement is to say that the analysis carried out has failed to discover any significant difference, if any at all, in the performances of the different samples on the tasks. However, one thing is sure: The sixth graders performed better than the fifth graders on the Piaget-like tasks and the fifth better than the fourth as shown by the summary of their scores below:

TABLE 24

MEANS AND STANDARD DEVIATIONS OF THE SUBJECTS ON THE PIAGET-LIKE TASKS

	SAMPLE DESCRIPTION		
	Primary Class Six	Primary Class Five	Primary Class Four
Sample Size	352	340	287
Means	7.06	6.65	6.41
Standard Deviations	1.70	1.50	1.58

Discussion: In general, the 979 subjects of this study could be judged to have performed fairly well on the Piaget-like tasks with a mean score of 6.74 (out of ten possible scores) and a standard deviation of 1.67. This implies that the subjects gave correct responses to over 67% of the queries on the Piaget-like tasks. However, the attention of the reader should be called to the fact that the subjects did very poorly on the first two activities of the Piaget-like tasks as shown on Table 25 (page 122).

In the first activity which dealt with conservation of distance in the presence of an interposed cardboard between two toy trees, less than 50% of the subjects were able to give correct answers and reasonable explanations for the query on this activity. In fact, only about 24% of the entire sample (see table on page 122) of this study gave correct response to the activity in question. The performance of the subjects in the second activity of the Piaget-like tasks was almost as poor as their performance on the first activity. In all, only 32% of the entire sample "believed" in conservation of length after one of the identical match sticks had been displaced a little bit to one side. However, the subjects seem to have done fairly well in the rest of the activities. This result is in consonance with Piaget's tenets that, all things being equal, most children in the age bracket of nine and twelve should have reached a concrete level of operation. And this fact might have been responsible for the failure to discover any significant difference between the performances of the fourth, fifth and sixth graders of this study.

TABLE 25

PERFORMANCES OF THE SUBJECTS ON THE PIAGET-LIKE TASKS

Item No.	Description of Tasks	% of Subjects giving correct Responses to the Tasks			
		Primary Class VI N = 350	Primary Class V N = 340	Primary Class IV N = 287	Entire Sample N = 979
1	Conservation of Distance	30.1	24.4	16.4	24.2
2	Conservation of Lengths	40.8	25.9	23.0	32.0
3	Conservation of Continuous Quantity	91.5	92.9	97.3	94.8
4	Conservation of Discontinuous Quantity	75.0	65.9	62.4	68.0
5	Conservation of Weight	76.1	65.9	67.6	70.1
6	Concept of Height	94.5	75.2	88.9	86.1
7	Concept of Displacement	99.0	93.5	97.3	97.5
8	Concept of Speed	83.5	67.6	58.2	70.5
9	Concept of Time	72.5	60.0	58.5	63.8
10	Concept of Relative Weight	98.5	97.1	91.2	96.0

It is germane at this juncture to relate the results of the performances of the sample of this study on the Piaget-like tasks to some of the theories invoked by Piaget. Of pertinence to this portion of this study are the following Piagetian theories:

(a) That conservation ability starts to develop at about the age of seven or eight in normal children; and that it reaches fruition at about the age of eleven or twelve,

(b) that although maturation is an important ingredient in the attainment of Piagetian stages of development, the ages at which different children reach a particular stage may vary due to a number of factors such as environment, and

(c) that conservation of quantity appears before that of weight and that the development of conservation ability in volume comes last.

Examining the results of the performances of the sample of this study (see Table 25 on page 122) in the light of the above theories, one could deduce the following conclusions:

1. That these subjects whose ages ranged from nine to about twelve have attained conservation abilities in continuous quantity, discontinuous quantity and weight. A large percentage of them, however, lack conservation abilities in distance and lengths. This might be due to the fact that there are not many tasks in the culture of the subjects which call for precise measurement.

2. That age is not the sole determinant in the attainment of Piagetian stages of development is vividly borne out by the

performances of the subjects on the third task. In this task, the fourth graders performed better than the fifth graders who in turn out-shone the sixth graders, and

3. that the performances of the subjects conform with the third Piagetian postulate above in that, while only 70.1 percent of the subjects are "conservers" of weight as many as 94.8 percent of them are conservers of continuous quantity.

Finally, it would not be an exaggeration on the basis of the results above, to assert that the generality of school children in the fourth, fifth and sixth grades in Western State of Nigeria have reached what Piaget termed "concrete level of operation" in the tasks covered in this study.

Hypothesis 5: That there is a difference in the performances of school children in the urban and non-urban areas of Western State of Nigeria on Piaget-like tasks.

The above hypothesis was tested by applying a t-test on the mean scores of the urban and non-urban subjects. A t-value of 3.58 which was found to be statistically significant at 0.01 level resulted from the t-test analysis. A confidence interval analysis yielded the following interval for the difference between the population means of the groups at 99% confidence level: $0.280 < M_1 - M_2 < 0.480$. And since this interval does not include zero, the investigator is 99% confident that there is a significant difference in the performances of urban and non-urban school children on the Piaget-like tasks in favour of the urban children.

Discussion: The urban children showed their superiority over their non-urban counterparts in almost all the activities of this study. For example, over 26% of the urban children gave correct responses to the first task as against 21.8% of the non-urban children. The same story is true for the second activity in which as many as 37.8% of the urban children got right against only 25.1% of their non-urban counterparts as shown in Table 26 below. The only reason which could be advanced for this disparity is that the urban child has a more enriching educational environment than the non-urban child as observed elsewhere in this paper.

TABLE 26

PERFORMANCES OF THE URBAN AND NON-URBAN SUBJECTS IN THE PIAGET - LIKE TASKS

Item No.	Percentage of Subjects Giving Correct Responses to the Tasks	
	Urban Sample N = 525	Non-Urban Sample N = 454
1	26.2	21.8
2	37.8	25.1
3	92.3	88.5
4	68.9	67.5
5	74.0	65.5
6	94.0	92.0
7	92.1	92.8
8	75.0	65.3
9	64.5	63.5
10	97.0	95.0

Hypothesis 6: That there is a positive correlation between the amount of incidental physical science knowledge possessed by school children of each grade of this study and their performances on Piaget-like tasks.

The above hypothesis was set-up to determine any relationship between incidental physical science knowledge and science-related Piaget-like tasks. It was found that there existed positive correlation coefficients (see Table 20 above), though weak, between the two forms of activities for each of the three grades covered by this study. And all the three correlation coefficients obtained were found to be statistically significant at 0.05 level according to Table D on page 236 of Elementary Statistics by Spence and others.

Discussion: It is important to note that one thing which both the physical science knowledge test and the science-related Piaget-like tasks of this study have in common is that they both deal with activities which are not taught in elementary schools in the State. The existence of positive correlations between the physical science knowledge test and the Piaget-like tasks and the statistical significance of the correlations for each grade could only be rationalized by saying that the two forms of activities deal with one and the same thing: Incidental knowledge. After all, incidental knowledge is the product of concept formation and the development of concepts is the cornerstone of Piagetian theories.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

In addition to the educational implications of the findings of this study, this chapter presents an overview of the research methodology and results.

5.1 Summary of Research Methodology

Six hypotheses were generated from the general statement of the problem of this study. These hypotheses are:

1. That elementary school children in Western State of Nigeria possess a better-than-chance knowledge of incidental physical science knowledge.

2. That there are differences in the nature and the amounts of incidental physical science knowledge possessed by the fourth, fifth and sixth graders in Western State of Nigeria.

3. That there are differences in the nature and the amounts of incidental physical science knowledge possessed by school children in the urban and non-urban areas of Western State of Nigeria.

4. That there is a difference in the performances of fourth, fifth and sixth graders on Piaget-like tasks.

5. That there is a difference in the performances of school children in the urban and non-urban areas of Western State of Nigeria on Piaget-like tasks.

6. That there is a positive correlation between the amount of incidental physical science knowledge possessed by school children of each grade of the study and their performances on Piaget-like tasks.

A multi-stage procedure was then employed in gathering and analyzing data for this study so as to be able to uphold or reject the hypotheses at specified confidence levels. The first step involved the construction and the validation of two research instrument called Physical Science Knowledge Test and Interview Guide for Piaget-like Tasks. The instruments were constructed by the investigator because none of the available tests were found to be suitable for this study.

A forty-item multiple-choice science knowledge test was devised after a thorough examination of the elementary school curriculum in Western State of Nigeria had been carried out. The essence of this exercise was to be certain that none of the items of the test was derived from the contents of elementary school curriculum in the State, since the thrust of this portion of the study was to examine the nature of incidental science knowledge possessed by the elementary school children in the State. The items of the test were then examined by a four-man panel of experienced elementary school teachers. The main duties of the panel were to ensure that none of the items of the test contained elements which are directly related to elementary school curriculum in the State and to see that the vocabulary and the sentence structures of the test were such that children in primary classes IV, V and VI in the State would be able to come to grips with. The deliberations of members of the panel resulted in the reduction of the forty-item test to a thirty-item test for a variety of reasons.[136]

And in order to further validate the science knowledge test, an item analysis of the thirty-item test was carried out. This involved the administration of the test on primary classes IV, V and VI pupils in both urban and non-urban schools in the State. But because of language problem, the original test had to be translated to Yoruba, the language of the population of this study. Armed with this Yoruba version[137] of the test, the investigator administered the test to fifty-four elementary school children in classes IV, V and VI of an urban school and fifty children in classes IV, V and VI of a non-urban school. Item analysis of their responses to the multiple-choice thirty-item test was then carried out. On the basis of the result of the item analysis, sixteen items[138] were culled from the thirty-item validation test. The sixteen items were then arranged according to their levels of

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136 For further details, See Chapter III.

137 See Appendix III.

138 See Appendix IV.

difficulty with the easiest item first and the most difficult item last. It is important to note that all the sixteen items selected fell within the range of twenty-five to seventy-five percent of computed levels of difficulty and also within +0.750 and +0.200 of computed discriminatory powers.[139]

The above exercise was followed by the administration of the sixteen-item test on 120 pupils selected from classes IV, V and VI of both urban and non-urban schools in order to determine its reliability. Using the split-half method and the Spearman-Brown formula, a reliability coefficient of 0.616 was obtained for the science knowledge test. This instrument later served as one of the final instruments for this study.

The interview guide for Piaget-like tasks, like the science knowledge test, underwent some modification before its final version was arrived at. First, the first draft of the guide which was later expanded from a fifteen-item guide to a twenty-item guide, was constructed by the investigator with the cultural milieu of the population of this study in mind. Second, copies of the twenty-item guide were given to a panel of three psychologists in the Faculty of Education, University of Ife, Nigeria, for validation purposes. And with little modifications,[140]

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[139] For more details, see Chapter III of this report.

[140] For details of the modifications, see the chapter on Research Methodology.

here and there, the panel unanimously agreed on ten items of the guide as replicating some of Piaget's experiments. The reliability of the guide was found to be 0.692 using the split-half method and the Spearman Brown formula on the performances of the same 120 subjects used for establishing the reliability of the science knowledge test.

The two research instruments were then administered on a total of 979 subjects from a random selection of elementary schools in one of the four education zones in the State. The breakdown of the 979 subjects according to class, sex and geographical locations is as follows:

TABLE 27

SAMPLE SIZE BY CLASS, SEX AND GEOGRAPHICAL LOCATIONS

	URBAN N-525		NON-URBAN N=454		
CLASSES	Boys	Girls	Boys	Girls	TOTAL
Primary Class VI	108	92	81	71	352
Primary Class V	80	88	92	80	340
Primary Class IV	80	77	65	65	287
Total	268	257	238	216	979

After the data gathering activity, the subjects' responses were subjected to item-by-item analysis and their scores on both instruments were subjected to both inferential and non-inferential statistical analyses. The types of analyses carried out were dictated by the nature of the hypotheses of this study as could be seen below.

5.2 Summary of Research Results

The item-by-item analysis of the responses of the subjects to the sixteen items of the multiple-choice science knowledge test revealed that whereas school children in Western State of Nigeria possess appreciable incidental science knowledge, their concepts of natural phenomena such as rain formation and rainbow are rooted in beliefs which pervade traditional Yoruba mythology and the animist religions of the Yorubas. For instance, while over fifty percent of the children know that liquid water undergoes a change of state at its boiling point as many as 46.5 percent of them think that "rain is formed by God" and another 12.1 percent of the children are of the opinion that "rain is formed from 'Sango,'" the traditional Yoruba god of thunder and lightning.

A list of the science concepts covered by the science knowledge test is given below with the percentage of the subjects who possess the concepts in the brackets after the concepts.

1. Telephone is a vehicle of communication (77.6%).

2. Sun is the chief source of light energy in the day in Nigeria (78.0%).

3. Refrigerator is a cooler (60.5%).

4. Iron ore is obtained from beneath the earth's crust (40.1%).

5. Evaporation is the process by which our wet clothes get dried (46.0%).

6. Electricity is a source of light and heat (40.2%).

7. Steam is the product of boiling water (51.6%).

8. Electricity is a source of energy for television (38.2%).

9. Tap water is a source of relatively clean, pure water (42.6%).

10. The moon's light is a reflection of the sun's light (30.8%).

11. Rainbow is a result of refraction of sun's rays through rain droplets (21.2%).

12. Electricity is a source of energy for radio (31.0%).

13. A working fan is capable of setting particles of air in motion (47.2%).

14. Rain is formed from clouds (16.8%).

15. A magnet is a piece of metal or stone which picks up nails, needles and pins (24.4%).

16. Rain water, unlike well water, does not contain dissolved solid matter (25.4%).

An ite by-item analysis of the performances of the 979 subjects on the ten activity items of the interview guide for Piaget-like tasks gave the following results:

1. 24.2% of the subjects are "conservers" of distance.

2. 32.0% of the subjects are "conservers" of length.

3. 94.8% of the subjects are "conservers" of continuous quantity.

4. 68.0% of the subjects are "conservers" of discontinuous quantity.

5. 70.1% of the subjects are "conservers" of weight.

6. 86.1% of the subjects possess the correct concept about height, in that they were able to build on lower surfaces towers which were identical to a reference tower.

7. 97.5% of the subjects possess the correct concept about displacement by predicting that some water would be displaced if an object is immersed in a vessel of water.

8. 70.5% of the subjects possess the correct concept about the distance-time relationship of speed by demonstrating the knowledge that speed is distance covered per unit time.

9. 63.8% of the subjects possess the correct concept about time in that they demonstrated that moving objects could cover different distances in the same time if they have different speeds.

10. 96.0% of the subjects possess the correct concept about relative weights by demonstrating that weight is not necessarily a direct function of size in that a smaller object may weigh more than a bigger object depending on their densities.

The item-by-item analysis of the responses of the subjects was followed by statistical analysis of their scores in the two research instruments. The statistical analysis was to test the significance or otherwise of the six hypotheses of this study. A t-value of 37.4 which was obtained for testing hypothesis 1 was found to be statistically significant at 99% confidence level and the difference between the population means was found to lie between 3.55 and 4.07. As the difference between the population means does not include zero, it may be asserted that there is 99% confidence that hypothesis 1 is true. For hypothesis 2, an F-value of 11.5, which was found to be statistically significant at 0.01 level, was obtained. A further statistical analysis revealed that there is a significant difference between the sixth graders and the rest of the population of this study. A t-test analysis carried out to test hypothesis 3, yielded a t-value of 9.77 which was found to be statistically significant at 99% confidence level in favour of the urban population. And the confidence interval computed for the difference between the population means was found to include only non-zero values (i.e. $1.43 < M_1 - M_2 < 1.75$) at 99% confidence level. But unlike the three hypotheses discussed so far, hypothesis 4 was found to be statistically insignificant. Hypothesis 5 was, however, found to be statistically significant at 0.01 level with a non-zero confidence interval. This result confirmed that there is 99% confidence that the performances of the urban children in the State on Piaget-like tasks are superior to those of their non-urban counterparts. And for the last hypothesis, hypothesis 6, low, but positive correlation coefficients were found to exist between the amount of incidental science knowledge possessed by the school childrean in each grade of this study and their performances on the Piaget-like tasks. The correlation coefficients were found to be statistically significant at 0.05 level.

5.3 Conclusions

Within the realm of the findings of this study, the following conclusions appear justified:

1. There appear to be widespread misconceptions about natural phenomena such as rainbow among elementary school children in Western State of Nigeria. These miconceptions are, no doubt, rooted in the traditional Yoruba mythology. On the whole, however, the children seem to possess appreciable incidental elementary knowledge concerning science-related elements in their environment.

2. The non-urban child appears to be handicapped, or at least disadvantaged, by the nature of the physical environment in which he lives. This observation is linked to the non-stimulating environment of the rural child where amenities such as television, cinema (movie) houses and the like are concerned.

3. The performances of the children on the Piaget-like tasks appear to a large extent, to be age-dependent with the older children performing better than the younger children. The over-all performance of the children could be said to be comparable with performances of other children in related studies including Piaget's. For instance, most of the children are found to be "conservers" of quantity, and weight in consonance with Piaget's findings:

> [That] the child discovers the conservation of substance and length at seven or eight. He develops the ability to conserve weight and the ability to coordinate horizontal and vertical axes at nine or ten.[141]

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[141] Jean Piaget, "How Children Form Mathematical Concepts," Scientific American, 189, p. 74, 1953.

4. Elementary school children in Western State of Nigeria appear to possess a better-than-chance knowledge of incidental physical science knowledge.

5. There appears to be differences in the nature and the amounts of incidental physical science knowledge possessed by the fourth, fifth and sixth graders in Western State of Nigeria.

6. There appear to be differences in the nature and the amounts of incidental physical science knowledge possessed by school children in the urban and non-urban areas of Western State of Nigeria.

7. There appears to be a difference in the performances of school children in the urban and non-urban areas of the State on the Piaget-like tasks.

8. There appears to be a positive correlation between the amount of incidental physical science knowledge possessed by school children of each grade of the study and their performances on the Piaget-like tasks.

5.4 Implications of Research Findings

Deriving from the findings of this study, a number of implications for science education in Western State of Nigeria appear justified.

The first and perhaps the most important implication of the findings of this study has to do with the cultural milieu of the population of this study. Needless to say that the teacher and curriculum developer should be aware of the fact that the average school child in the State (and in the whole country as a matter of fact) is going through a period of difficult, and probably rapid and sweeping, transitional changes culturally in the sense that he lives in a world where two diametrically opposed cultures (the old, traditional and the new cultures) co-exist. It is left to the classroom teacher and the curriculum developer to find ways and means of bridging the gap between these two cultures, in the most ameliorative way. A child who brings to the school the "notion" that "lightning is generally sent by 'Sango,' the Yoruba god of thunder and lightning, to incapacitate or even kill evil-doers" has 'learned' something from his old culture. But in the light of what is known to be scientifically true today about the cause of lightning, such a child's notion is not just far from being scientific, it may be labelled "superstitious." So, there is a need to replace any superstitious knowledge the child may possess as a result of local myths, witchcraft and divination. For without doing this, the school might be creating a lot of confusion in the mind of the child by simply presenting notions which are diametrically opposed to the ones held by the child and his parents. It is the contention of the investigator that with patience, understanding and knowledge of how children learn, the classroom teacher and the science curriculum planner can help the child to learn science concepts with ease and enjoyment. Implied in the above statement, however, is the fact that every teacher and every curriculum worker in the State are aware of rampant science misconceptions among school children as a result of their cultural background. In addition, both the teacher and the curriculum designer should be prepared to treat such misconceptions with understanding instead of just dismissing them as superstitious. This might be done by exploring the origin of the misconceptions with the children and then indicating that such explanations of the phenomena in question are no longer tenable in this day and age.

The second implication of the findings of this study is related to the fact that the minds of school children in the State are not tabula rasa as far as science concepts are concerned. Both the teacher and the science curriculum developer should be aware of this fact and strive to make the science concepts that the child has been able to come to grips with the springboard of the science experiences of the child.

Thirdly, the findings concerning the Piaget-like portion of this study have implications for content selection and grade placement. For example, since it was found that children in classes four, five and six of elementary schools in Western State of Nigeria are "conservers" in a number of areas, science concepts dealing with two variables at a time are within their realm of understanding provided that such concepts are dealt with concretely. So, school children of comparable ages as those of this study could profit from experimental treatment of concepts such as the distance-time relationship of speed or the weight-distance relationship of see-saw mechanism.

Fourthly, the findings of the Piaget-like portion of this study have implications for teaching methods. The teaching of youngsters in this level of development should place emphasis on objects, actual experiences, visual aids, field trips and project method. This is because children at concrete operational thought would profit more from teaching when they are in a position to relate the substance of the lesson directly to objects than in a position where they are left to their imagination and perception. After all, children learn a great deal from objects as well as acting on objects.

Lastly, the findings of this study have implications for the State Government. It was established somewhere in this paper, that the significant differences which are found to exist between the urban and the non-urban children are believed to be in favour of the urban children because of the presence of educationally stimulating modern amenities in the urban centres of the State. In order to correct this anomaly, it is hoped that the State's government would come to the rescue of the rural child by providing him with educationally stimulating modern equipment, which would allow him to stand in good stead to his urban brother. It is no exaggeration to say that any money that is spent in this respect is a good investment since over fifty percent of the State's population are non-urban dwellers. The provision of electricity by the government and the availability of television, tap water and libraries in the rural areas of the State would, hopefully, have salutary effects on the intellectual growth of the rural child.

5.5 Further Research Indices

It would be presumptuous of the investigator of this study to pretend that this study has unearthed all that is to be known about the nature of incidental science learnings among children in Western State of Nigeria. Far from it! If anything at all, this study should be regarded as a drop of water in an ocean of needed researches in this field. But if the drop could generate ripples large enough to catch the attention of science curriculum developers in the State and create foci for discussing ways and means of improving science education in the elementary schools in the State, then this study would have achieved part of its intentions.

In the light of the experiences gained during the course of this study, the investigator would like to recommend further research work in the following areas:

1. An extension of the study to other geographical and linguistic areas of Nigeria.

2. The initiation of a study to determine the nature of incidental biological science knowledge possessed by school children who are not yet exposed to any form of science instruction in the elementary schools in the State. The findings of such a study together with the findings of this study might provide a better understanding about commonly held science concepts as well as misconceptions about different branches of science among school children in the State.

3. A study of science misconceptions based on Yoruba mythology among school children in Western State of Nigeria.

In addition to the above list of areas in which further research work is recommended, the following questions could be raised as well.

1. Why did the population of this study perform much better on the activity dealing with conservation of continuous quantity (in the Piaget-like portion of this study) than on the activities dealing with conservation of distance and lengths even though all these conservation abilities are postulated to develop synchronously by Piaget?

2. Why did the subjects perform much better on the activity dealing with conservation of continuous quantity than that of discontinuous quantity?

Needless to say that it is the contention of the investigator that empirical evidences would be needed in order to provide adequate answers to these questions.

APPENDICES

APPENDIX I

THE FIRST DRAFT OF THE PHYSICAL SCIENCE KNOWLEDGE TEST

Physical Science Knowledge Test

Directions: Read each item of the test carefully and decide which best answers the question. Mark your answers on the separate answer sheet provided. Indicate your answer by circling out the corresponding letter on the answer sheet. Your score will be the number of right answers, so it will be to your advantage to attempt every question. Do not write on the test booklet.

First Draft

I. Physical phenomena:

1. Electricity can produce:

   (a) sun and warmth
   (b) air and water
   (c) light and heat
   (d) sun and heat
   (e) I don't know

2. Electricity is carried through:

   (a) rope
   (b) wire
   (c) water
   (d) air
   (e) I don't know

3. Electricity can be used to work our:

   (a) fans, televisions and radios
   (b) houses, lawns and fields
   (c) cats, dogs and goats
   (d) none of the above
   (e) I do not know

4. A piece of metal or stone which picks up nails, needles and pins is:

   (a) a hammer
   (b) a magnet
   (c) a magic
   (d) none of the above
   (e) I do not know

5. When a bar magnet is suspended by a piece of string:

   (a) it faces a particular direction
   (b) it faces any direction
   (c) it faces no direction
   (d) it faces east
   (e) I do not know

6. The chief source of light in the day in Nigeria is:

   (a) the moon
   (b) the sun
   (c) the god
   (d) the electric bulb
   (e) I do not know

7. The image formed by a mirror is:

   (a) in front of it
   (b) at the side of it
   (c) at the back of it
   (d) at the edge of it
   (e) I do not know

8. When water is boiling some of it turns to:

   (a) steam
   (b) ice
   (c) solid
   (d) none of the above
   (e) I do not know

9. Our wet clothes on the line get dry due to:

   (a) boiling
   (b) god
   (c) evaporation
   (d) respiration
   (e) I do not know

10. When a piece of iron bar is heated:

(a) it becomes longer
(b) it becomes shorter
(c) it becomes heavier
(d) none of the above
(e) I do not know

11. When a cube of sugar is put into a cup of water, the bubbles that are given off are due to:

(a) escaping (particles of) sugar
(b) escaping (particles of) water
(c) escaping (particles of) cup
(d) escaping (particles of) air
(e) I do not know

12. If a mixture of a little salt and sand is put into a cup of water and stirred:

(a) the salt will "disappear" (dissolve in the water) leaving the sand at the bottom of the cup
(b) the sand will "disappear" (dissolve in the water) leaving the salt at the bottom of the cup
(c) both the salt and the sand will "disappear"
(d) both the salt and the sand will not "disappear"
(e) I do not know

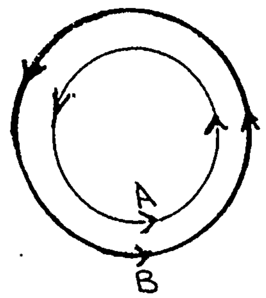
13. Iron is obtained from:

(a) air
(b) water
(c) sky
(d) earth
(e) I don't know

14. The earth is:

(a) a flat object
(b) a round object
(c) a square object
(d) a rectangular object
(e) I do not know

15. Two boys (A and B) are running round two different circles (see below) - Boy A around the inner circle and Boy B around the other circle. They both start at the same time and arrive at their starting points at the same time after one complete revolution (running round the circle once).



Boy A is running:

(a) faster than Boy B
(b) at the same speed as Boy B
(c) slower than Boy B
(d) none of the above
(e) I don't know

16. Air is essential to man because he:

(a) breathes out air
(b) breathes in air
(c) needs air
(d) loves air
(e) I don't know

17. How can one show that air is necessary for burning?

(a) by eating
(b) by fanning
(c) by burning
(d) by drinking
(e) I don't know

18. Why is it that rain water is purer than water from the well?

(a) because rain water does not contain dissolved solid substances
(b) because rain water comes from "heaven"
(c) because rain water contains dissolved solid substances
(d) because rain water comes from God
(e) I don't know

19. An empty bottle is full of:

    (a) nothing
    (b) water
    (c) liquid
    (d) air
    (e) I don't know

20. If a bottle is half filled with water, the other half of the bottle contains:

    (a) air
    (b) nothing
    (c) liquid
    (d) water
    (e) I don't know

II. Natural Phenomena

21. Night is caused by:

    (a) the magic of God
    (b) the magic of Sango
    (c) the total disappearance of the sun
    (d) man's feeling for sleep
    (e) I don't know

22. Moon gets its light energy from:

    (a) the moon itself
    (b) the sun
    (c) the god of moon
    (d) the witch
    (e) I don't know

23. An eclipse (osan di oru) can be caused by:

    (a) the earth covering the rays of the moon
    (b) the sun cutting off its rays from the earth
    (c) the god of sun holding the rays of the sun in his hand
    (d) the moon covering the rays of the sun
    (e) I don't know

24. Thunder is a:

(a) sound caused by the explosion in the clouds
(b) sound caused by the electricity in the clouds
(c) sound caused by the god of rain in the clouds
(d) sound caused by the goddess of rain in the clouds
(e) I don't know

25. In case,we have thunder and lightning, which one do we notice first ?

(a) thunder
(b) lightning
(c) both at the same time
(d) none of the above
(e) I don't know

26. Rain is formed from:

(a) God
(b) Sango
(c) clouds
(d) sun
(e) I don't know

27. After rain the wet ground may become dry because of the fact that:

(a) the rain water is sucked up by the soil
(b) the rain water is weightless
(c) the rain water is god's water
(d) none of the above
(e) I don't know

28. Rainbow (esumare) is caused by:

(a) the god of rain
(b) the evil wish of witches
(c) the rays of the sun on "rain drops"
(d) the rays of the moon on "rain drops"
(e) I don't know

29. Day and night are caused by:

    (a) the movement of the sun from east to west
    (b) the movement of the moon round the earth
    (c) the movement of the earth round the earth
    (d) the movement of the earth on its axis
    (e) I don't know

30. Sun is:

    (a) a touch light
    (b) a powerful source of light
    (c) a touch light of God
    (d) a powerful source of cold
    (e) I don't know

31. Rain is caused by:

    (a) evaporation and condensation
    (b) thunder and lightning
    (c) rainbow and sunlight
    (d) none of the above
    (e) I don't know

III. Utilities

32. Tap water is good for our health because:

    (a) it is sweeter than well water
    (b) it is dirtier than well water
    (c) it is more colourful than well water
    (d) it is cleaner than well water
    (e) I don't know

33. Telephone wire (cable) is used in carrying:

    (a) sound from one place to another
    (b) air from one place to another
    (c) gas from one place to another
    (d) water from one place to another
    (e) I don't know

34. Telephone can be used to:

(a) talk to our friends
(b) see our friends
(c) love our friends
(d) none of the above
(e) I don't know

35. Television uses:

(a) water
(b) air
(c) electricity
(d) sound
(e) I don't know

36. A working fan causes:

(a) water to move fast
(b) air to move fast
(c) sound to move fast
(d) none of the above
(e) I don't know

37. A fridge (refrigerator) is used to make things (e.g. coca-cola drink):

(a) hotter
(b) warmer
(c) colder
(d) none of the above
(e) I don't know

38. A radio uses:

(a) sound
(b) electricity
(c) water
(d) none of the above
(e) I don't know

39. An electric bulb gives us light because of:

(a) the cooling of the wire in the bulb
(b) the heating of the wire in the bulb
(c) the heating of the glass of the bulb
(d) none of the above
(e) I don't know

40. An oil stain in our dress can be removed by:

(a) gum
(b) glue
(c) blue
(d) kerosene
(e) I don't know.

APPENDIX II

THE SECOND DRAFT OF THE PHYSICAL SCIENCE KNOWLEDGE TEST

Physical Science Knowledge Test

Directions: Read each item of the test carefully and decide which best answers the question. Mark your answers on the separate answer sheet provided. Indicate your answer by circling out the corresponding letter on the answer sheet. Your score will be the number of right answers, so it will be to your advantage to attempt every question. Do not write on the test booklet.

Second Draft

1. Electricity can produce:

   (a) sun and water
   (b) air and water
   (c) light and heat
   (d) sun and moon

2. Electricity can be used to work our:

   (a) fans, televisions and radios
   (b) houses, lawns and fields
   (c) cats, dogs and goats
   (d) clothes, paper and books

3. A piece of metal or stone which picks up nails, needles and pins is:

   (a) a hammer
   (b) a magnet
   (c) a magic
   (d) a mortar

4. The chief source of light in the day in Nigeria is:

   (a) the moon
   (b) the sun
   (c) the god
   (d) the electric bulb

5. The image formed by a mirror is:

   (a) in front of it
   (b) at the side of it
   (c) at the back of it
   (d) at the edge of it

6. When water is boiling some of it turns to:

   (a) steam
   (b) ice
   (c) solid
   (d) salt

7. Our wet clothes on the line get dry due to:

   (a) boiling
   (b) god
   (c) evaporation
   (d) respiration

8. When a piece of iron bar is heated:

   (a) it becomes longer
   (b) it becomes shorter
   (c) it becomes heavier
   (d) it becomes darker

9. If a mixture of little salt and sand is put into a cup of water and stirred:

   (a) the salt will "disappear" (dissolve in the water) leaving the sand at the bottom of the cup
   (b) the sand will "disappear" (dissolve in the water) leaving the salt at the bottom of the cup
   (c) both the salt and the sand will "disappear"
   (d) both the salt and the sand will not "disappear"

10. Iron is obtained from:

   (a) air
   (b) water
   (c) sky
   (d) earth

11. The earth is:

   (a) a flat object
   (b) a round object
   (c) a square object
   (d) a rectangular object

12. Air is essential to man because he:

   (a) breathes out air
   (b) breathes in air
   (c) needs air
   (d) loves air

13. Why is it that rain water is purer than water from the well?

   (a) because rain water does not contain dissolved solid substances
   (b) because rain water comes from "heaven"
   (c) because rain water contains dissolved solid substances
   (d) because rain water comes from God

14. If a bottle is half filled with water, the other half of the bottle contains:

   (a) air
   (b) nothing
   (c) liquid
   (d) water

15. Night is caused by:

   (a) the magic of God
   (b) the magic of Sango
   (c) the total disappearance of the sun
   (d) man's feeling for sleep

16. Moon gets its light energy from:

   (a) the moon itself
   (b) the sun
   (c) the god of moon
   (d) the witch

17. In case we have thunder and lightning, which one do we notice first?

    (a) thunder
    (b) lightning
    (c) both at the same time
    (d) none of the above

18. Rain is formed from:

    (a) God
    (b) Sango
    (c) cloud
    (d) sun

19. After rain the wet ground may become dry because of the fact that:

    (a) rain water is sucked up by the soil
    (b) rain water is weightless
    (c) rain water is god's water
    (d) none of the above

20. Rainbow (esumare) is caused by:

    (a) the god of rain
    (b) the evil wish of witches
    (c) the rays of the sun on "rain drops"
    (d) the rays of the moon on "rain drops"

21. Day and Night are caused by:

    (a) the movement of the sun from east to west
    (b) the movement of the moon round the earth
    (c) the movement of the earth round the earth
    (d) the movement of the earth on its axis

22. Sun is:

    (a) a touch of light
    (b) a powerful source of light
    (c) a touch of God
    (d) a powerful source of cold

23. Tap water is good for our health because

(a) it is sweeter than well water
(b) it is dirtier than well water
(c) it is more colourful than well water
(d) it is cleaner than well water

24. Telephone wire (cable) is used in carrying:

(a) sound from one place to another
(b) air from one place to another
(c) gas from one place to another
(d) water from one place to another

25. Telephone can be used to:

(a) talk to our friends
(b) see our friends
(c) love our friends
(d) none of the above

26. Television uses:

(a) water
(b) air
(c) electricity
(d) sound

27. A working fan causes

(a) water to move fast
(b) air to move fast
(c) sound to move fast
(d) none of the above

28. A fridge (refrigerator) is used to make things (e.g. coca-cola drink):

(a) hotter
(b) warmer
(c) colder
(d) none of the above

29. A radio uses:

(a) sound
(b) electricity
(c) water
(d) none of the above

30. An oil stain in our dress can be removed by:

(a) gum
(b) glue
(c) blue
(d) kerosene.

APPENDIX III

THE YORUBA VERSION OF THE SECOND DRAFT OF PHYSICAL SCIENCE KNOWLEDGE TEST

IBERE LORI EKO [illegible]

Ka gbolohun kọọkan pẹlu ifarabalẹ̀, ki o si fa idahun ti o ba rò pe o tọ̀nà julọ fun un yọ. Fi ami idahun rẹ han lori iwe - idahun ti a fi fun ọ. Fi idahun rẹ han nipa yiyi òfo ka lẹta idahun ti o ba tọ̀nà. Iye idahun ti o tọ̀nà nikan ni a o pè ni iye ti o gbà; nitori náà anfani tirẹ ni yio jẹ bi o ba dahun olukuluku ibeèrè.

Maṣe kọ iwe sori iwe idanwo.

1. Ina mọ̀nàmọ́ná lè fun wa ni:

   a. Oòrun ati ọmi

   b. Afẹfẹ ati omi

   d. Imọ́lẹ̀ ati ooru

   e. Oòrun ati Oṣupá

2. A le lo ina mọ̀nàmọ́ná lati jẹ ki awọn nkan wọnyi ṣiṣẹ:

   a. Fánù, tẹlifiṣọn ati redio

   b. Ile, ilẹ ati oko

   d. Ologbo, aja ati ewurẹ

   e. Aṣọ, beba ati iwe.

3. Nkan bi irin tabi okuta ti o ba lè gbé iṣo, abẹrẹ ati pini, ni a n pè ni:

   a. Nkan ikanṣo

   b. Ẹmú tàbí ẹ̀mọ́

   d. Nkan meremere o idán

   e. Odo.

4. Ohun ti o nfun wa ni imọlẹ ni ọsan ni:

   a. Osupa

   b. Oòrun

   d. Orișa

   e. Ina mọnamọna

5. Ojiji wa ti a ba ri ninu jigi máa n wa ni:

   a. Iwaju jigi

   b. Ẹ̀gbẹ́ jigi

   d. Lẹhin jigi

   e. Eti tabi igun jigi.

6. Ti omi ba n ho, apakan rẹ maa ndi:

   a. Eriru, ooru

   b. Omi yinyin (ice), omi dídì tabi yìnyín

   d. Okuta (solid), nkan rìgìdì

   e. Iyọ (salt), iyọ̀

7. Awọn aṣọ tutu ti a ba sa maa n gbẹ nitori:

   a. Hihó rẹ

   b. Orisa

   d. Imooru inu afẹfẹ

   e. Emimi mímí

8. Ti a ba fi ọpa irin sinu ina:

   a. Yio gun sii
   b. Yio kúrú sii
   d. Yio wuwo sii
   e. Yio dúdú sii.

9. Ti a ba bu iyọ ati iyanrin sinu ife omi ti a si roo pọ:

   a. Iyọ yio pòórá sinu omi, yio si ku iyanrin nikan sinu ife, ni isalẹ omi.

   b. Iyanrin yio pòórá, yio si ku iyọ nikan sinu ife.

   d. Iyọ ati iyanrin yio pòórá

   e. Iyọ ati iyanrin ki yio poora.

10. Nibo ni a ti nri irin tutu?

   a. Ninu afẹfẹ

   b. Ninu omi

   d. Ni ofurufu

   e. Ninu ilẹ.

11. Aiye jẹ:

   a. Ohun ti o tẹju pẹrẹsẹ

   b. Ohun ti o ri roboto

   d. Ohun ti o ni igun mẹrin ti o dọgba .

   e. Ohun ti o ni igun mẹrin ti ko dọgba.

12. Afẹfẹ jẹ ohun ti o ṣe pataki fun eniyan nitori wipe:

   a. A nmi afẹfẹ sita

   b. A nmi afẹfẹ sinu

   d. A nilo afẹfẹ

   e. A fẹran afẹfẹ.

13. Kini idi rẹ ti omi ojo fi mọ ju omi inu kanga lọ?

   a. Nitoripe ohun kankan ko pòórá sinu omi òjò

   b. Nitoripe lati oju ọrun ni omi ojo ti wa

   d. Nitoripe ọpọ nkan ni o ti pòórá sinu omi ojo (omi ojo ni eriri).

   e. Nitoripe omi ojo wa lati ọdọ Ọlọrun.

14. Bi a ba rọ omi sinu igo de idaji, idaji igo ti o ku yio kun fun:

   a. afẹfẹ

   b. ofifo

   d. nkan olomi

   e. omi.

15. Kini o nfa òru tabi ọ̀ganjọ́?

   a. Idán ti Ọlọrun pa ni

   b. Idán ti Ṣango pa ni

   d. Aisi oòrun rara ni

   e. Oorun ti eniyan n fẹ sun ni.

16. Osupa ngba agbara imọlẹ rẹ lati ọdọ

   a. Osupa funrarẹ

   b. Orun

   d. Orisa osupa

   e. Àjẹ́.

17. Ewo ni a ko maa nsakiyesi nigbati ààrá ba ṣán tabi ti mọ̀nàmọ́ná ba kọ?

a. aara

b. mọnamọna

d. mejeeji nigba kanaa

e. Ko si ikankan ninu awọn nkan ti a kọ soke yi.

18. Kini o nfa ojo?

a. Ọlọrun

b. Sango

d. Ìkùku

d. Oorùn.

19. Lẹhinti ojo ba rọ̀, ilẹ tutu le di gbigbẹ nitori pe

a. Ilẹ yio fi omi ojo náà mu.

b. Omi ojo kò wuwo

d. Omi ojo jẹ omi oriṣa.

e. Ko si kankan ninu awọn nkan ti a kọ soke yi.

20. Ohun ti o nfa osumare ni:

a. Oriṣa òjò

b. Ero buburu awọn àjẹ̀

d. Itansan oorun lori ẹkán òjò.

e. Itansan oṣupa lori ẹkan òjò.

21. Kini o nfa ọsan ati oru?

a. Yiyi oorun lati ila oorun si iwọ oorun.

b. Yiyi osupa yipo ayé

d. Yiyi ayé yipo ayé

e. Yiyi ti aye nyi bíríbírí ni.

22. Oorun jẹ:

a. Ina alafọwọyi

b. Orisun ina ti a lagbara

d. Ina Ọlọrun ti o nfi ọwọ yi

e. Orisun otutu ti o lagbara.

23. Omi ẹrọ dara fun alafia wa nitori pe:

a. O dun ju omi kànga lọ

b. O ni eéri ju omi kanga lọ

d. O ni awọ didan ju omi kanga lọ

e. O mọ ju omi kanga lọ.

24. A maa nlo okun tẹlifoonu (telephone) lati:

a. Fi sọrọ lati ibikan si ekeji

b. Fi gbe afẹfẹ lati ibikan si ekeji

d. Fi gbe nkan bi afẹfẹ lati ibikan si ekeji

e. Fi gbe omi lati ibikan si ekeji.

25. A le lo Tẹlifoonu (Telephone)

a. Lati fi ba ọrẹ wa sọrọ

b. Lati ri ọrẹ wa

d. Lati fẹran ọrẹ wa

e. Ko si ọkankan ninu awọn ohun ti a ti sọ.

26. Tẹlifiṣọn a máa lo:

a. Omi

b. Afẹfẹ

d. Ina mọ̀nàmọ́ná

e. Ohùn (sound).

27. Abẹ̀bẹ̀ ti ina mọ̀nàmọ́ná n yi a maa jẹ ki

a. Omi sare

b. Atẹgun sare

d. Ohun sare

e. Ko si kankan ninu awọn wọnyi.

28. Firíjì (fridge) a máa mu nkan

a. gbona gan

b. gbona diẹ

d. tutu gan

e. ko si kankan ninu awọn wọnyi.

29. Redio a máa lo:

a. ohùn (sound)

b. Ina mọ̀nàmọ́ná

d. Omi

e. Ko si kankan ninu awọn wọnyi.

30. A le mu abawọn epo kuro lara aṣọ wa nipa lilo:

a. gọ́ọ̀mu

b. ẹ̀mọ́ awọn Kafinnta

d. bulúù

e. epo oyinbo tabi karosini.

APPENDIX IV

BOTH THE ENGLISH AND YORUBA VERSIONS OF THE THIRD DRAFT OF THE PHYSICAL SCIENCE KNOWLEDGE TEST

Physical Science Knowledge Test

Directions: Read each item of the test carefully and decide which best answers the question. Mark your answers on the separate answer sheet provided. Indicate your answer by circling out the corresponding letter on the answer sheet. Your score will be the number of right answers, so it will be to your advantage to attempt every question. Do not write on the test booklet.

Third Draft

1. Telephone can be used to:

   (a) talk to our friends
   (b) see our friends
   (c) love our friends
   (d) none of the above

2. The chief source of light in the day in Nigeria is:

   (a) the moon
   (b) the sun
   (c) the god
   (d) the electric bulb

3. A fridge (refrigerator) is used to make things (e.g. coca-cola drink):

   (a) hotter
   (b) warmer
   (c) colder
   (d) none of the above

4. Iron is obtained from:

   (a) air
   (b) water
   (c) sky
   (d) earth

5. Our wet clothes on the line get dry due to:

   (a) boiling
   (b) god
   (c) evaporation
   (d) respiration

6. Electricity can produce:

   (a) sun and water
   (b) air and water
   (c) light and heat
   (d) sun and moon

7. When water is boiling some of it turns to:

   (a) steam
   (b) ice
   (c) solid
   (d) salt

8. Television uses:

   (a) water
   (b) air
   (c) electricity
   (d) sound

9. Tap water is good for our health because:

   (a) it is sweeter than well water
   (b) it is dirtier than well water
   (c) it is more colourful than well water
   (d) it is cleaner than well water

10. Moon gets its light energy from:

   (a) the moon itself
   (b) the sun
   (c) the god of moon
   (d) the witch

11. Rainbow (esumare) is caused by:

(a) the god of rain
(b) the evil wish of witches
(c) the rays of the sun on "rain drops"
(d) the rays of the moon on "rain drops"

12. A radio uses:

(a) sound
(b) electricity
(c) water
(d) none of the above

13. A working fan causes:

(a) water to move fast
(b) air to move fast
(c) sound to move fast
(d) none of the above

14. Rain is formed from:

(a) God
(b) Sango
(c) cloud
(d) sun

15. A piece of metal or stone which picks up nails, needles and pins is:

(a) a hammer
(b) a magnet
(c) a magic
(d) a mortar

16. Why is it that rain water is purer than water from the well?

(a) because rain water does not contain dissolved solid substances
(b) because rain water comes from "heaven"
(c) because rain water contains dissolved solid substances
(d) because rain water comes from God.

IBEÈRÈ LORI EKỌ SAYẸNSI

Ka gbolohun kọọkan pẹlu ifarabalẹ̀, ki o si fa idahun ti o ba rò pe o tọ̀nà julọ fun un yọ. Fi ami idahun rẹ han lori iwe - idahun ti a fi fun ọ. Fi idahun rẹ han nipa yiyi ọ̀fo ka lẹta idahun ti o ba tọ̀nà. Iye idahun ti o tọ̀nà nikan ni a o pè ni iye ti o gbà; nitori náà anfaani tirẹ ni yio jẹ bi o ba dahun olukuluku ibeèrè.

Maṣe kọ iwe sori iwe idanwo.

1. A le lo Tẹlifoonu (Telephone)
   - a. Lati fi ba ọrẹ wa sọrọ
   - b. Lati ri ọrẹ wa
   - d. Lati fẹran ọrẹ wa
   - e. Ko si ọkankan ninu awọn ohun ti a ti sọ.

2. Ohun ti o ń fun wa ni imọlẹ ni ọsan ni:
   - a. Oṣupa
   - b. Oòrun
   - d. Oriṣa
   - e. Ina mọnamọna

3. Firíjì (fridge) a máa mu nkan
   - a. gbona gan
   - b. gbona diẹ
   - d. tutu gan
   - e. ko si kankan ninu awọn wọnyi.

4. Nibo ni a ti ń ri irin tutu?

a. Ninu afẹfẹ

b. Ninu ọmi

d. Ni ofurufu

e. Ninu ilẹ

5. Awọn aṣọ tutu ti a ba sa máa ń gbẹ nitori:

a. Hihó rẹ

b. Orisa

d. Imooru inu afẹfẹ

e. Emimi mími

6. Ina mọ̀nàmọ́ná lè fun wa ni:

a. Oòrun ati omi

b. Afẹfẹ ati omi

d. Imọ́lẹ̀ ati ooru

e. Oòrun ati Oṣupá

7. Ti omi ba ń ho, apakan rẹ máa ń di:

a. Eriru tabi ooru

b. Omi yinyin (iọe), omi dídi tabi yìnyín

d. Okuta (solid), nkan rìgìdì

e. Iyọ (salt), iyọ̀

8. Tẹlifiṣọn a máa lo:

   a. Omi

   b. Afẹfẹ

   d. Ina mọ̀nàmọ́ná

   e. Ohùn (sound.)

9. Omi ẹrọ dara fun alafia wa nitori pe:

   a. O dun ju omi kànga lọ

   b. O ni eéri ju omi kànga lọ

   d. O ni awọ didan ju omi kanga lọ

   e. O mọ ju omi kanga lọ.

10. Oṣupa ń gba agbara imọlẹ rẹ lati ọdọ

   a. Oṣupa funrarẹ

   b. Oòrun

   d. Oriṣa oṣupa

   e. Awọn àjẹ́.

11. Ohun ti o ń fa osumare ni:

   a. Oriṣa òjò

   b. Ero buburu awọn àjẹ̀

   d. Itansan oọ̀run lori ẹkán òjò.

   e. Itansan oṣupa lori ẹkan òjò.

12. Redio a máa lo:

    a. ohùn (sound)

    b. Ina mọ̀nàmọ́ná

    d. Omi

    e. Ko si kankan ninu awọn wọnyi.

13. Abẹ̀bẹ̀ ti ina mọ̀nàmọ́ná ń yi a máa jẹ ki

    a. Omi sare

    b. Atẹgun sare

    d. Ohun sare

    e. Ko si kankan ninu awọn wọnyi.

14. Ki ni o ń fa ọ̀jọ̀?

    a. Ọlọrun

    b. Ṣẹrgo

    d. Ikùku

    e. Oòrun.

15. Nkan bi irin tabi okuta ti o ba lè gbé iṣo, abẹrẹ ati pini, ni a ń pe ni:

    a. Nkan ikanṣo

    b. Ẹmú tàbí ẹ̀mọ́

    d. Nkan meremere

    e. Odo

16. Ki ni idi ṛẹ ti omi òjò fi mọ ju omi inu kanga lọ?

a. Nitori pe ohun kankan ko pòórá sinu omi òjò

b. Nitori pe lati oju ọrun ni omi òjò ti wa

d. Nitori pe ọpọ nkan ni o ti pòórá sinu omi òjò (omi òjò ni eriri.)

e. Nitori pe omi òjò wa lati ọdọ Ọlọrun.

IDAHUN LORI EKO SAYENSI

Name: ______________________ Class: __________ Sex: ________

Town: ______________________

1.	a	b	d	e
2.	a	b	d	e
3.	a	b	d	e
4.	a	b	d	e
5.	a	b	d	e
6.	a	b	d	e
7.	a	b	d	e
8.	a	b	d	e
9.	a	b	d	e
10.	a	b	d	e
11.	a	b	d	e
12.	a	b	d	e
13.	a	b	d	e
14.	a	b	d	e
15.	a	b	d	e
16.	a	b	d	e

APPENDIX V

FIRST AND SECOND DRAFTS OF THE INTERVIEW GUIDE FOR PIAGET-LIKE TASKS

Interview Guide for Piaget-like Tasks
(First Draft)

A. Conservation of Matter.

1. Apparatus: Equal quantities of water in two similar glasses and one empty dissimilar (tall and narrow) glass.

   Direction: Pour the quantity of water from one of the similar glasses into the empty glass.

   Question: Is the amount of water in the two containers having water now the same? If yes, why? If no, why not?

2. Apparatus: A Rubber Band.

   Direction: The subject is asked to observe the stretchability of the rubber band.

   Question: Does the stretched rubber band have the same amount of rubber now as it had before stretching; or does it have less or more rubber in the stretched position? Explain your answer.

3. Apparatus: A piece of chalk.

   Direction: With the aid of a mortar and pestle, powder up the piece of chalk.

   Question: Does the powdered chalk still have the same amount of chalk it had before powdering? If so, why? If no, why not?

4. Apparatus: A big local nut or bead.

   Direction: Break the nut or bead into two or more pieces.

   Question: Do the broken pieces together have the same amount of nut or bead as the original nut or bead? If yes, why? If no, why not?

B. Concept of Weight.

5. Apparatus: Two plasticine (or mud) balls - with embedded lead shots in the smaller ball.

Direction: Inspect the two balls for their relative weights.

Question: Which is heavier, the bigger ball or the smaller ball? Explain your answer. How can you prove your stand?

6. Apparatus: A piece of chalk.

Direction: Break the piece of chalk into three parts.

Question: Does the original piece of chalk weigh the same amount as the broken pieces put together? If yes, why? If no, why not?

C. Concept of Speed.

7. Apparatus: Two toy cars.

Direction: Two toy cars moving in the same direction but separated by a distance of about one foot at the beginning of their journeys.

Question: If they both reach line A (same destination) at the same time, do the two cars have equal or different speeds; which one is faster? And why? If not different, why not?

8. Apparatus: Two racing toy cars.

Direction: Stop car A at the instant it is catching up (overtaking) with car B.

Question: Which car is faster, A or B? And why?

D. Concept of Length and Measurements.

9. Apparatus: Sixteen identical wooden squares.

Direction: Observe the tower built on the table with wooden squares (N.B. Make a six-piece tower.) Make an identical tower on the nearby lower table using some of the remaining squares.

Question: How do you know they are identical? i.e. are they of the same height?

10. Material: Two match sticks.

Direction: Put the match sticks side by side. Are they of equal length?

Question: Now move one of them a little to the right (about 1/5th inch). Are they still of the same length? If yes, why? If no, why not?

E. Nature of Air.

11. Apparatus: Clapping of hands.

Direction: Clap your two hands in a position very close to your face.

Question: What do you feel? Where does what you feel come from? How do you know this?

12. Apparatus: Punctured rubber ball.

Direction: Press (squeeze) the punctured rubber ball to deflate it. Observe the escaping air by putting the hole of the punctured rubber ball near your cheek as the ball is being deflated.

Question: Does this show that air is around us though we can't see it? Explain your answer.

F. Level of Water.

13. Apparatus: A glass three-quarters full of water and a pebble.

Direction/ Question: Suppose the pebble is put into the glass of water, will the level of water rise or decrease? And why? Put the pebble gently into the glass of water and notice the new level of the water. Why is this so?

14. Apparatus: Two identical glasses with equal amount of water and two dissimilar pebbles (different sizes).

Direction/ Question: Which of the two pebbles will displace more water? And why? Put the two pebbles into the glasses of water; one pebble for each glass and observe the new levels of water in the glasses. Explain your observation. And why does this happen?

G. Concept of Area

15. Apparatus: Two paper-cut-out areas; one is long, but thin and the other squarish.

Direction: Inspect the two areas and compare their relative sizes.

Question: Which of the areas is larger?

FROM:
A. A. Taiwo

TO:

REF.: Ta/002   DATE: 3/12/73

Piaget-like Tasks

I write to solicit your co-operation in the validation of one of my research instruments.

I shall be very grateful if you can indicate (probably by asterisk), suitable tasks for Piaget-like experiments in the attached Interview Guide for Piaget-like Tasks.

Other pertinent comments and observations (even a conference with you), are welcomed.

Thanks for your co-operation.

A.A. Taiwo

Interview Guide for Piaget-like Tasks

(Second Draft)

A. Conservation of Distance, Length, Substance, and Weight.

1. Material: Two toy trees and a cardboard.

   Direction: Call the attention of the subject to the fact that the two toy trees are separated by a known distance (say 12"). Ask him to place a tall cardboard mid-way between the two trees.

   Question: Are the trees still separated by the same distance; are they closer together or farther away from each other now? Give the reason(s) for your answer.

2. Material: Two match sticks.

   Direction: Put the match sticks side by side on the table. Are they of equal length?

   Question: Now move one of them a little to the right (about 1/5th inch). Are they still of the same length? If yes, why? If no, why not?

3. Material: Two equal parallel rows of sticks of matches.

   Direction: Arrange one of the rows of matches to form a figure like this:

   Question: Is the entire length of the figure the same as the length of the second row of matches? If yes, why? If no, why not?

4. Material: Equal quantities of water in two similar tumblers and one empty dissimilar (tall and narrow) tumbler.

   Direction: Pour the water in one of the similar tumblers into the empty tumbler.

   Question: Is the amount of water in the two containers having water now the same? If yes, why? If no, why not?

5. Material: A piece of chalk.

   Direction: With the aid of mortar and pestle, powder up the piece of chalk carefully.

   Question: Does the powdered chalk still have the same amount of chalk as it had before powdering? If so, why? If no, why not?

6. Material: A rubber band.

   Direction: Observe the stretchability of the rubber band.

   Question: Does the stretched rubber band have the same amount of rubber now as it had before stretching; or does it have less or more rubber in the stretched position? Give reason(s) for your answer.

7. Material: A big local nut or bead.

   Direction: Break the nut or bead into two or more pieces.

   Question: Do the broken pieces put together have the same amount of nut or bead as the original nut or bead? If yes, why? If no, why not?

8. Material: Any liquid and several containers.

   Direction: Pour some of the liquid into three other containers.

   Question: Is the weight of the liquid in the four containers now the same as the weight of the original liquid? If so, why? If not, why not?

9. Material: A ball of plasticine.

   Direction: Feel the weight of the ball in your hand. Cut the ball into two and feel the weight of the two halves together.

   Question: Is the weight of the two halves of ball more or less than the weight of the original ball? Or do they weigh the same as the original ball? Give reason(s) for your answer.

B. Concepts of air, classification, measurement, sinking, speed, time and gravity.

10. Material: A small piece of cardboard.

    Direction: Fan yourself with the piece of cardboard. What do you feel?

    Question: Does this mean that air occupies space? Explain your answer.

11. Material: Punctured rubber ball.

    Direction: Squeeze the punctured rubber ball to deflate it. Observe the escaping air by putting the hole of the punctured rubber ball near your cheek as the ball is being deflated.

    Question: Does this show that air is around us though we cannot see it? Explain your answer.

12. Material: Four red wooden cubes, four black wooden cubes, four red wooden pyramids, and four black wooden pyramids.

Direction: Sort the given objects into different groups.

Question: What is the basis of your classification? Give reasons for your classification basis. (Resort the objects using different classification basis.)

13. Material: Sixteen identical wooden cubes.

Direction: Observe the tower built on the table with wooden cubes (N.B. Make a six-piece tower). Make an identical tower on the nearby lower table using some of the remaining cubes.

Question: How do you know they are identical?

14. Material: A tumbler three-quarters full of water, pebble and a piece of coloured chalk.

Direction: Mark the level of water in the container. Put the pebble gently into the water and mark the new level of water in the container.

Question: What is the rise in water level due to? Explain your answer.

15. Material: Two identical containers with equal amount of water and two dissimilar pebbles (one large and light, other small and heavy).

Direction: Observe the levels of water in the two containers. Gently put the two pebbles into the containers; one pebble for each container and note the new levels of water in the containers.

Question: Why is there any difference in the increases in the levels of water in the containers? (i.e., why does one pebble displace more water than the other?) Explain your answer.

16. Material: Two toy cars.

Direction: Two toy cars moving in the same direction but separated by a distance of about one yard at the beginning of their journeys.

Question: If they started their journeys at the same time and they both reached line A (the same destination) at the same time, was one of the cars faster than the other? If yes, which one was faster and why? If no, why not?

17. Material: Two racing toy cars (A and B).

Direction: With car B starting before car A from their common place of departure, stop car A at the instant it is catching up (overtaking) with car B.

Question: Is one of the cars faster than the other? If so, which one and why? If not, why not?

18. Material: Two racing dolls, A and B. (Doll A moves faster than Doll B).

Direction: Observe the two dolls racing across the table. They are started and stopped at the same time. Observe that Doll A covered a greater distance than Doll B.

Question: Do the dolls take equal time to cover their respective distances? If yes, why? If no, why not?

19. Material: Two plasticine (or mud) balls - with embedded lead shots in the smaller ball.

Direction: Inspect the two balls for their relative weights.

Question: Which is heavier, the bigger ball or the smaller ball? Explain your answer.

20. Material: A piece of stone

Direction: Hold it up in the air and let go.

Question: Why does it fall to the ground? Explain your answer.

Piaget-like Tasks (Apparatus)

1. Two toy trees and a large cardboard
2. Match sticks
3. Rubber bands
4. Beads or local nuts
5. Plasticine or mud
6. Coloured cubes, pyramids (8 black and 8 red)
7. Identical squares (16)
8. Two toy cards
9. Two dolls
10. Two similar glasses and one dissimilar glass
11. Punctured rubber ball
12. Two dissimilar pebbles
13. Pieces of coloured chalk.

APPENDIX VI

THE THIRD DRAFT OF THE INTERVIEW GUIDE

FOR PIAGET-LIKE TASKS

Interview Guide for Piaget-Like Tasks

(Third Draft)

1. Material: Two toy trees and a cardboard.

   Direction: Call the attention of the subject to the fact that the two toy trees are separated by a known distance (say 12"). Ask him to place a tall cardboard midway between the two trees without displacing any of the toy trees.

   Question: Has the distance between the trees changed or is it still the same? If the answer to the first part of the question is "yes," then ask whether they are closer or farther away from each other. Give reason(s) for your answer. If the answer to the second part of the question is "yes," ask the subject to give reason(s) for his response.

2. Material: Two equal match sticks.

   Direction: Call the attention of the subject to the fact that the match sticks are equal in length. Put two match sticks side by side on the table (parallel to each other). Are they of equal length? Displace one of the two match sticks a little so that the ends of the two matches are moved about 1/5 of an inch from each other.

   Question: Are they still of the same length? If yes, why? If no, why not?

3. Material: Equal quantities of water in two similar tumblers and one empty dissimilar tumbler (tall narrow tumbler).

   Direction: Call the attention of the subject to the fact that the similar tumblers contain equal quantities of water. Pour the water in one of the similar tumblers into the empty dissimilar tumbler.

   Question: Is the amount of water in the two containers having water now the same? If yes, why? If no, why not?

4. Material: Two equal pieces of chalk.

Direction: With the aid of mortar and pestle, powder up one of the pieces of chalk carefully.

Question: Does the powdered chalk still have the same amount of chalk as it had before powdering? If so, why? If no, why not?

5. Material: Two identical balls of plasticine.

Direction: Feel the weight of the balls in your hand or put each of the identical balls on the pans of the beam balance provided. (Notice that the beam is level and the pointer points to zero mark.) Cut one of the balls into two portions and compare the weight of the two portions with the uncut one by either of the methods above.

Question: Is the weight of the two halves of the ball more or less than the weight of the original ball? Or do they weigh the same as the original ball? Give reason(s) for your answer.

6. Material: Sixteen identical wooden cubes.

Direction: Observe the tower built on the table with wooden cubes (N.B. Interviewer makes a six-piece tower). Make an identical tower on the nearby lower table using some of the remaining cubes.

Question: Is your tower the same as the one you saw earlier? Give reason(s) for your answer.

7. Material: Two identical tumblers with equal quantities of water, pebble, and a piece of coloured chalk.

Direction: Mark the levels of water in the containers with the piece of chalk. Predict what will happen to water level in one of the containers if a pebble is gently put into it. Then, put the pebble gently into the water in one of the containers and mark the new level of water in the container.

Question: What is the rise in water level due to? Explain your answer.

8. Material: Two toy cars.

Direction: Two toy cars moving in the same direction but separated by a distance of about one yard at the beginning of their journeys.

Question: If the two cars started their journeys at the same time and one of them was one yard behind the other at the beginning of their journeys, why do they reach the same destination at the same time? Give reason(s) for your answer.

9. Material: Two racing dolls, A and B. (Doll A moves faster than Doll B).

Direction: Observe the two dolls racing across the table from a common origin - they started and stopped at the same time. Observe that Doll A covered a longer distance than Doll B.

Question: Do the dolls take equal time to cover their respective distances? If yes, why? If no, why not?

10. Material: Two plasticine (or mud) balls - with embedded lead shots in the smaller ball.

Direction: With the aid of a beam balance or otherwise. compare the relative weights of the balls.

Question: Which is heavier, the bigger ball or the smaller ball? Explain your answer.

Apparatus for Piaget-like Tasks

1. Two toy trees and a cardboard
2. Match sticks
3. Two similar glasses and one dissimilar glass
4. Coloured pieces of chalk, mortar and pestle
5. Identical balls of plasticine and a beam balance
6. Sixteen identical wooden cubes
7. Pebble
8. Two toy cars
9. Two racing dolls
10. Lead shots and plasticine
11. Pieces of coloured chalk.

Interview Guide for Piaget-like Tasks

Answer Sheet

Name of Subject ____________________ Sex __________

Name of Town ______________________ Class _________

Item No.	Correct response	Incorrect response	Reason(s) Given			Special Reasons Offered
			Reason-able	Unreason-able	Uncertain	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

APPENDIX VII

THE ENTIRE SYLLABUS FOR ELEMENTARY SCHOOLS IN NATURE STUDY AND GARDENING AND PAST EXAMINATION QUESTIONS IN THOSE "SCIENCE-RELATED" SUBJECTS FOR PRIMARY CLASS SIX PUPILS

WESTERN STATE OF NIGERIA
ELEMENTARY SCHOOL CURRICULUM
THE SYLLABUS
FOR
NATURE STUDY AND GARDENING

In Classes I and II one weekly period is sufficient but in Classes III to VI three weekly periods are necessary. Girls to have the extra period by doing Needlework while boys are doing Crafts. Nature Study and Gardening will be regarded as ONE subject in the Time-table.

The teaching of outdoor and class activities must be completely integrated to encourage and develop the child's natural powers of observation and enquiry. A Nature Corner (table) should be kept by every class.

CLASS I

Simple talks drawing the attention of the children to living things around them throughout the seasons. Encourage children to report what they have seen.

Walks to observe natural activities in the surrounding bush and compound. Observe planting and harvesting operations on local farms and growth and development of local animals, e.g., kids, chicks. Feeding and growth of all living things to be carefully noted.

Collect brightly coloured seeds, leaves, fruits, etc.

Plant seeds in a small corner of the school garden and in milk tins. Let children uproot these at will.

Weather observations.

A Nature Corner.

CLASS TWO

Plant small vegetable and flower beds to allow children to play at gardening. Water, weed and thin growing plants.

Growth of plants from seed to be watched more closely. Name root, steam, leaves, flower, fruit and seed.

Some of the harmful animals which eat crops, e.g., caterpillars, squirrels, bushfowls, goats, sheep, etc.

Useful animals which destroy pests, e.g., geckos, spiders and domesticated animals which protect, feed and are friendly with men (e.g., dogs, cats, cows, sheep, chickens).

Common birds and insects. Learn the vernacular names of a few. Build a bird-table. Collect feathers.

Talks and visits to continue as in Class I. Notice especially local grasses, trees and weeds.

CLASS THREE

Practical work, walks and talks as before.

Soil, need for food and water before plants grow. Simple observations and demonstrations to illustrate these points.

Animals - need for food and water. Encourage children to keep and discuss the care of domestics, e.g., dogs, goats, poultry - teaching kindness and a sense of responsibility to animals.

Recognise more useful animals - bees, butterflies, praying mantis.

Recognise more harmful animals - grasshoppers, beetles, bush-rats.

Collect: Specimens for a simple Nature Table and include flowers of different colours.

CLASS FOUR

Simple Gardening, as before.

Soil fertility.

Collection of compost material and the planting of legumes (e.g., ground-nuts or cowpeas) on bare piece of garden.

Thin seedlings of flowers and vegetables. Let children appreciate competition for food, water and light.

Soil structure - simple explanations; sand and clay.

Germination of common seeds, e.g., maize, cowpeas. Watch roots growing downwards, leaves upward and notice foodstuff in seed or seed leave.

Birds - nesting and food gathering activities of birds common in the locality, e.g., weaver birds, swallows, cattle egrets. Notice different colours, shapes of beaks.

External appearance and habits - of fish, lizard.

Nature Table (to include flowers of different shapes).

Simple drawings of plants and animals. Observe, compare and draw flowers collected.

CLASS FIVE

Vegetable beds - lay out with regard to shape, size, straightness, fertility, use of crossbars. Seed boxes. Compost making.

Plant flowers, shrubs and flowering trees to beautify school compound. Learn names of these.

Plant propagation by cuttings.

Simple anti-erosion measures.

Simple properties of clay, sand, loam demonstrated.

Air - simple experiments to show presence of air, need for air by all living things.

Flower parts of waterleaf or other common simple flower. Note flower stalk, sepals, petals, stamens and pistil.

Roots - common types of tap and of fibrous.

Steams - common types of erect and climbing.

Leaves - notice colour and shape. Need for light.

Earth worms and termites in the soil.

External appearance and habits of spiders, scorpions, crayfish, millipedes and centipede.

Observe habits, beaks, and feet of birds of prey (Hawk), scavengers (vultures), tree climbers (parrots), water birds (ducks), nectar sippers (sunbirds), insect eaters (egrets). (See "Common Birds of West Africa.")

Study: Wasps.

Nature Corner.

CLASS SIX

Class form plot bearing a four-course rotation. Compost making.

Planting and care of fruit trees. Methods of plant propagation - seeds cuttings, mulching.

Care of existing trees - pruning.

Water in the soil - water table, capillarity, evaporation.

Decomposition in the soil - simple treatment.

Pollination - observe part played by the main agencies (especially bees, butterflies, moths, wind birds).

Fruits - development from flower to be observed. Dry and fleshy fruits.

Seed Dispersal - observe and draw simple examples.

Breeding cages - e.g., life cycle butterfly, mantis.

Study - life cycles of house fly and malaria mosquito.

Habits and external appearance of any six of the following mammals: cow, pig, duiker, cat, dog, sheep, elephant, pangolin, squirrel, cutting grass, porcupine, monkeys, apes, pottes, guinea-pigs, giant-rats.

SOME PAST EXAMINATION QUESTIONS IN THE SCIENCE-RELATED SUBJECTS

(On the Primary School Leaving Certificate Examination)

NATURE STUDY AND GARDENING

1. A dog is a MAMMAL because of ONE of the following:

   (a) it can bark
   (b) it hunts animals
   (c) it watches the master's house
   (d) it has hair and feeds its young with milk

2. Animals and plants are living things because of ONE of the following:

   (a) they cannot reproduce themselves
   (b) they die through accident or old age
   (c) they cannot breathe
   (d) they do not grow

3. The chief work of the flower to the plant is ONE of the following:

   (a) to beautify the plant
   (b) to produce seeds
   (c) to attract insects
   (d) to protect the plant

4. How many legs has a True Insect? ______________(4 legs; 6 legs; 8 legs)

5. Which one of the following must be done to keep water safe for drinking?

   ____

   (i) Add sugar and salt to water
   (ii) Allow the water to settle properly
   (iii) Boil the water

6. What name is given to the green colouring matter present in leaves?

   ____

7. Which ONE of the following steps should we take to stop mosquito-breeding?

____

(i) Keep bushes around the house
(ii) Don't let water remain in empty tins and broken bottles
(iii) Continue to use blankets

8. Which part of the air keeps us alive? ______________________________

____

(i) Carbon-dioxide
(ii) oxygen
(iii) nitrogen

GARDENING

1. What is the planting distance of TOMATO on the bed? (1 1/2 feet; 2 1/2 feet; 3 feet)

____

2. Of the following four kinds of soil, which ONE do you consider the best for vegetables?

____

(i) a sandy soil
(ii) a clayey soil
(iii) the top soil
(iv) a loamy soil

3. Why do we prepare the soil for planting?

____

(i) to soften the soil for easy movement of roots and for the rapid growth of plants
(ii) to destroy harmful insects
(iii) to obtain additional soil
(iv) to prevent erosion

4. Which ONE of the following creatures is useful to a gardener?

(i) beetle
(ii) earthworm
(iii) grasshopper

5. When transplanting, which part of a seedling should NOT be destroyed?

(i) leaves
(ii) branches
(iii) root hairs

6. An insect-pest in the garden is ONE of the following:

(i) a bee
(ii) a grasshopper
(iii) a spider
(iv) a toad

7. "Mulching" means ONE of the following: ______

(i) covering the soil with dry grass or leaves
(ii) adding plenty of water to the soil
(iii) allowing overcrowding on vegetable beds

8. In planting vegetables, we take to correct planting distances because of ONE of the following: ______

(i) to prevent excessive evaporation
(ii) to avoid overcrowding
(iii) to check weeds
(iv) to allow more air into the soil.

APPENDIX VIII

RAW SCORES OF THE 104 PUPILS WHOSE SCORES WERE SUBJECTED TO ITEM ANALYSIS

Raw Scores of the 104 Pupils whose Scores were subjected to Item Analysis

1	5	36	11	71	16
2	6	37	12	72	16
3	7	38	12	73	16
4	7	39	12	74	16
5	7	40	12	75	16
6	7	41	12	76	17
7	7	42	12	77	17
8	8	43	13	78	17
9	8	44	13	79	17
10	8	45	13	80	17
11	8	46	13	81	17
12	8	47	13	82	17
13	8	48	13	83	17
14	8	49	13	84	17
15	9	50	13	85	17
16	9	51	13	86	17
17	9	52	13	87	17
18	9	53	14	88	18
19	9	54	14	89	18
20	9	55	14	90	18
21	9	56	14	91	18
22	10	57	14	92	18
23	10	58	14	93	18
24	10	59	14	94	18
25	10	60	14	95	19
26	10	61	15	96	19
27	11	62	15	97	19
28	11	63	15	98	20
29	11	64	15	99	21
30	11	65	15	100	21
31	11	66	15	101	21
32	11	67	15	102	21
33	11	68	15	103	25
34	11	69	16	104	26
35	11	70	16		

Mean score = 13.58

Average difficulty value = 45.28%

APPENDIX IX

RESULTS OF THE ANALYSES OF RELIABILITY DATA FOR THE TWO RESEARCH INSTRUMENTS

A. Results of the Analysis of Reliability Test for the Physical Science Knowledge Test

N	=	120
ΣX	=	468.0000
ΣY	=	427.0000
ΣXY	=	1793.0000
ΣX^2	=	2066.0000
ΣY^2	=	1861.0000

Correction coefficient between two halves of the tests — $r_{1/2} = 0.4453$

Reliability coefficient of the whole test — $R = 0.6162$

Spearman-Broom Formula

$$R = \frac{2\,r_{1/2}}{1 + r_{1/2}}$$

B. Results of the Analysis of Reliability Test for the Interview Guide for Piaget-like Tasks

N	=	120
ΣX	=	371.0000
ΣY	=	383.0000
ΣXY	=	1253.0000
ΣX^2	=	1275.0000
ΣY^2	=	1355.0000

Correlation coefficient between two halves of the guide — $r_{1/2} = 0.5288$

Reliability coefficient of the whole guide — $R = 0.6918$

APPENDIX X

A COPY OF THE LETTER TO THE INSPECTOR OF EDUCATION IN CHARGE OF OSUN/IFE/IJESHA ZONE AND THE RESPONSE TO THE LETTER

FACULTY OF EDUCATION

TA/001/

November 1, 73.

Mr. J. Oloyede
Principal Inspector of Education,
Ministry of Education,
Inspectorate Division,
Osogbo.

Dear Sir,

List of Elementary Schools
in your Zone
by name and address

I write to solicit your cooperation in an on-going research involving elementary schools in Western State of Nigeria.

I would be very grateful if a list of elementary schools in your zone (by name and address) could be made available to me by return post. I enclose a stamped self-addressed envelope for rapid handling.

Thank you for your cooperation.

Yours faithfully,

A. A. TAIWO

Ref. No. OFI. 68/64.

Provincial Education Office,
Ministry of Education,
P.M.B. 335,
Osogbo.

8 November, 1973.

Mr. A. A. Taiwo,
Faculty of Education,
University of Ife,
Ile - Ife.

Dear Mr. Taiwo,

List of Elementary Schools in
Osun/Ife/Ijesa Zone.

Thank you for your letter of 1st November, 1973 in which you were asking for the list of Primary Schools in this zone.

2. I attach herewith the list and I hope it will help you in your research work.

3. Wish you luck.

Principal Inspector of Education,
Osun/Ife/Ijesa Zone.

APPENDIX XI.

LIST OF SCREENED SINGLE-STREAMED ELEMENTARY SCHOOLS IN IFE TOWNSHIP AND ITS RURAL ENVIRONS

List of Qualified Schools (in terms of single arm classes) in Ife Township and environs

Urban Schools

1. St. Bernards RCM, Lagere, Ife
2. Ethiopian National, Okejan, Ife
3. Methodist, Sabo, Ife
4. L. A. School, Ilesha Bye-Pass, Ife
5. L. A. School, Fewara Road, Ife
6. A. T. D. Oke-Atan, Ife
7. Salvation Army, Oke-Atan, Ife
8. C. A. C. Iloro, Ife
9. The Apolostic Oke-Soda, Ife
10. St. Stephen's "B" Modakeke, Ife
11. St. Math's Modakeke, Ife
12. Salvation Army, Modakeke, Ife
13. L. A. School, Aruda-Oba, Modakeke, Ife
14. St. Stephen's "C" Modakeke, Ife
15. St. John's School, Ilare, Ife

Non-Urban Schools

1. St. Jude's, Moro
2. C. A. C., Moro
3. St. John's, Yakoyo
4. L. A. School, Ajebandele
5. L. A. School, Ilala, Owena
6. St. Peter's A/C Bowaje Owena
7. L. A. School, Fania
8. St. Paul's, Fania
9. The Apostolic, Bale Sanyo
10. Anglican United, Ononi Salako
11. St. James, Oyo/Odeyinka
12. St. Andrew's, Kinkinyinhun
13. St. Andrews, Toro
14. St. Raphael's, Toro
15. L. A. School, Ejesi
16. St. John's, Oye/Lowa
17. The Apostolic, Idita
18. L. A. School, Oyere Kereja
19. United Anglican, Aye-Oba
20. St. Mark's R. C. M., Yekeni
21. St. Stephen's, Ajebandele
22. St. Michael's, Odobule
23. Sacred Heart, Ogbagba
24. C. A. C., Obaluru

25. C.A.C., Eleja Onikoko
26. C.A.C., Eleja Elesin
27. St. John's, Wanikin
28. St. Lawrence, Wanikin
29. St. Paul's, Iyanfoworogi
30. Coker Memorial, Erefe
31. L. A. School, Osu
32. St. Paul's, Akakowe
33. Methodist, Oke-oni, Osu
34. Methodist, Oke-oja, Osu.

APPENDIX XII

LIST OF SCHOOLS QUALIFIED FOR SCIENCE EQUIPMENT BY ZONE

Elementary Science Equipment Grant to
Primary Schools - Western State
Ijebu/Egba Zone

1. Ijebu Division

    1. All Saints, Atikori, Ijebu, Igbo
    2. St. Joseph's R.C.M., Obada, Ijebu, Igbo
    3. St. Peter's Anglican, Idowa, Ijebu Ode
    4. Moslem School, Isoku, Ijebu Ode
    5. St. Paul's Anglican, Odogbolu
    6. Methodist, Igan, Ago-Iwoye

2. Remo Division

    7. Mayflower Junior School, Ikenne
    8. St. Paul's Makun, Sagamu
    9. St. John's R.C.M., Iperu
    10. Wesley Methodist, Isara
    11. St. Barnaba's Ilishan
    12. United Methodist, Ipara

3. Egba Division

    13. St. Peter's Anglican, Ake, Abeokuta
    14. St. Paul's Demonstration, Ibara, Abeokuta
    15. All Saints, Owode, via Abeokuta
    16. St. Jane's Anglican, Orile Ilugun
    17. A.U.D. Practising, Otta
    18. Methodist, Ogbe, Abeokuta

4. Egbado Division

    19. L.A. Eredo, Ilaro
    20. A.U.D. Ajilete, Ilaro
    21. Methodist, Ado Odo, via Lagos
    22. L.A. Ilashe, Ilaro
    23. Christ Church Anglican, Ilaro
    24. United Primary, Aiyetoro, Egbado

5. Ibadan City

    1. St. James' Cathedral, Oke-Bola, Ibadan
    2. Wesley College Practising, Elekuro, Ibadan
    3. I.C.C. S4, Elekuro, Ibadan
    4. St. Stephen's Anglican, 'Nalende, Ibadan

5. U.M.C. Demonstration, Molete, Ibadan
6. Aladura Mission, Oke Bola, Ibadan

6. Ibadan Division (North)

7. St. Andrew's Anglican, Omi Adio
8. Ebenezer Anglican, Akingbile
9. St. Paul's Anglican, Oyedeji
10. St. Andrew's Anglican, Dally
11. St. Anthony's, Ejioku
12. All Saints, Araromi-Aperin

7. Ibadan Division (South)

13. A.U.D., Igboora
14. L.A. Oke, Eruwa
15. Baptist, Eruwa
16. African, Lanlate
17. Baptist, Lanlate
18. R.C.M., Igboora

8. Oyo North Division

19. L.A. Taba, Shaki
20. Baptist, Ago Are
21. L.A. Olele, Okeho
22. N.U.D., Igbeti
23. Baptist, Oke Afin, Igboho
24. R.C.M., Tede

9. Oyo South Division

25. St. Andrew's Demonstration, Oyo
26. St. Mary's Anglican, Iyalamu, Oyo
27. St. Paul's Anglican, Iseyin
28. Methodist, Iware
29. L.A. Ikoyi
30. 1st Baptist, Fiditi

Ife/Ilesha/Osun Zone

10. Ife Division

1. All Saints' Anglican, Aiyegbaju, Ife
2. St. Peter's Anglican, Iremo, Ife
3. A.U.D., Ogbondo, Ife
4. St. Stephen's "A" Modakeke, Ife

5. L.A. Akarabata, Ife
6. Ethiopian Central, Modakeke, Ife

11. Ijesha North Division

7. L.A. Ijeda via Ilesha
8. L.A. Imesi Ile via Ilesha
9. St. Peter's Anglican, Erinno
10. St. Paul's, Ipety 'Jesha
11. St. Mathew's "A" Ijebu 'Jesha
12. R.C.M. Ibokun

12. Ijesha South Division

13. St. Stephen's "A" Ifewara, Ilesha
14. Holy Trinity "A" Omofe, Ilesha
15. Holy Trinity "B" Omofe, Ilesha
16. Methodist Ogudu, Ilesha
17. C.A.C., Okesa, Ilesha
18. Methodist, Oke Oja, Oshu

13. Osun Central Division

19. All Saint's, Osogbo
20. Methodist, Osogbo
21. St. Peter's Anglican, Ede
22. D.S. School, Obada, Ede
23. Young Tajudeen, Iragberi via Ede
24. St. John's Anglican, Ifon via Osogbo

14. Osun North East Division

25. Methodist School, Ikirun
26. St. Mathew's Anglican, Ila Orogun
27. St. Stephen's Anglican, Ora
28. African Church, Oyan
29. St. Andrew's Anglican, Ada via Ikirun
30. St. Mary's Anglican, Igbaye via Ikirun

15. Osun North-West Division

31. Methodist, Obada via Ogbomosho
32. Methodist, Box 9, Ogbomosho
33. Baptist, Ori Oke, Ogbomosho
34. D.C. School, Masifa, Ogbomosho
35. Oke Moyo, Baptist, Ejigbo
36. A.U.D., Ejigbo

16. Osun South Division

37. St. Paul's Anglican, Gbongán
38. St. John's Anglican, Ikire
39. D. C. Ilegbo
40. Ansar Ud-Deen, Ode Omu
41. Baptist, Oke Odo, Iwo
42. St. Peter's African Church, Kuta

Ondo Zone

17. Ondo Division

1. Messiah African Church, Ondo
2. Ansar-Ud-Deen, 40 Barracks Road, Ondo
3. Methodist School, P.O. Box 75, Ondo
4. St. Peter's Anglican, Ile Oluji
5. St. Joseph's R.C.M., Oke Igbo
6. St. Peter's Anglican, 'Bolorunduro

18. Akure Division

7. L.A. School I, Akure
8. Sacred Heart, Akure
9. St. Mathew's Anglican, Iju via Akure
10. St. George's Anglican, Idanre
11. Anglican School, Ilara
12. St. Paul's Anglican, Igbara Oke

19. Okitipupa Division

13. Methodist, Okitipupa
14. Methodist, Igbobino via Okitipupa
15. St. Paul's Anglican, Okitipupa
16. St. Peter's R.O.M., Ode Irele
17. Ebenezer African Church, Ilutitun
18. St. Pius, Igbotako

20. Owo Division

19. Ansar-Ud-Deen I, Box 52, Owo
20. St. Andrew's Anglican, Owo
21. L.A. School, Ifon
22. St. Michael's A/C, Owo
23. St. Francis R.C.M., Owo
24. St. Paul's Anglican, Ifon

21. Akoko Division

25. Ansar-Ud-Deen School I, Ikare
26. St. John's African, Ipe Akoko
27. St. Peter's R.C.M., Iwaro, Oka
28. Holy Trinity Anglican, Akungba
29. St. John's Anglican, Ogbagi
30. St. George's Anglican, Oke-Agbe

22. Ekiti Central

31. Harding Memorial, Ado-Ekiti
32. St. Thomas' Aquinas, Ado-Ekiti
33. Ansar-Ud-Deen School, Oke-Illa, Ado-Ekiti
34. Community "A" Iyin Ekiti
35. Baptist, Igede Ekiti
36. Holy Trinity, Aisegba, Ekiti

23. Ekiti North Division

37. St. John's Anglican, Egosi Ekiti
38. St. Peter's Anglican,Ikole-Ekiti
39. Methodist School, Aiyedun
40. St. Mary's R.C.M., Omuo
41. Methodist School, Itapa
42. St. Peter's Anglican, Aiyede

24. Ekiti South Division

43. L.A. Emure, Ekiti
44. St. John's African Church, Ikere-Ekiti
45. St. Paul's R.C.M., Igbara Odo
46. St. Peter's C.A.C., Ilawe Ekiti
47. St. Mark's Anglican, Ise Ekiti
48. L.A. School, Okekere, Ikere Ekiti

25. Ekiti West Division

49. St. Philip's Anglican, Aramoko-Ekiti
50. St. Stephen's C.A.C., Efon-Alaye
51. St. Andrew's Anglican, Ushi Ekiti
52. Community, Omodewa, Iddo Ekiti
53. St. Peter's R.C.M., Ijero Ekiti
54. S.D.A., Otun Ekiti

Summary

	Zone	No. of Schools
1.	Ijebu Egba	24
2.	Ibadan/Oyo	30
3.	Oshun/Ife/Ilesha	42
4.	Ondo	54
		150

APPENDIX XIII

WESTERN STATE - GOVERNMENT'S PAPER ON ELEMENTARY SCIENCE PROGRAMME IN THE STATE

PRIMARY SCHOOL ELEMENTARY SCIENCE PROGRAMME

WESTERN STATE

1. INTRODUCTION - The present Elementary Science Programme was introduced into Western State in 1965.

2. SYLLABUS - Prior to 1965, the current primary school syllabus has Nature Study/Gardening/Health as a composite subject.

   (a) Primary School Elementary Science Syllabus: The first draft of the present, Elementary Science Syllabus compiled for Primary Classes V and VI only, came into being in 1965. This was experimented in seven schools in Ibadan Township in 1965/66. The teachers using the draft syllabus who had a Grade II General Science qualification were regularly given weekend induction courses during the trial period of the Syllabus.

   Officers of the ministry also went round to see these teachers at work. A critique Committee was set up which regularly reviewed the topics in the light of the experiences gained by the teachers and officers observations. In 1968, The final draft of the primary School Science Syllabus, Western State was approved, and has since been in use.

   (b) Grade II General Science Syllabus: The introduction of General Science into our Teacher Training Colleges was of recent, so not many Grade II Teachers with General Science background were in the field. The training of primary school teachers who will use the new primary school Science Syllabus became imperative.

To equip such teachers academically, a Grade II General Science Syllabus was compiled, and put to use in the Science Courses at the Science-In-Service Centres.

3. PRIMARY SCHOOL SCIENCE DEVELOPMENT

(a) Courses: Even though most of our Grade II Teacher Training Colleges are now including General Science in their curricula, few Grade II teachers are still being turned out with General Science qualification.

To quicken the pace of introducing elementary science into all our primary schools in the State, a form of In-Service Course has been introduced since 1967.

i. Evening Classes - Grade II teachers with Nature Study or Rural Science background are put through the Grade II General Science syllabus for a year. This course is for teachers resident in towns.

ii. Vacation Course - Teachers of the same qualification as in "i" above who teach in the district come during the three vacations in the year to attend a two week intensive course every term.

iii. Induction - Teachers who have successfully completed the evening classes or the vacation course, also Grade I Rural Science teachers and Grade II teachers with General

Science qualification usually attend this course (Methodology) designed to equip the teachers with the method of teaching science to a primary school pupil.

(b) Science In-Service Centres.

i. Science-In-Service Centres came into being at the inception of Primary School Science in 1966. The only centre in Ibadan in 1966, has since grown into eight in the State, i.e., two centres in each of the four educational zones of the State. Sub-centres have also been created in each zone. At present, we have a total of twelve Sub-In-Service Centres in the State.

ii. Qualified Primary School Science Teachers. The number of teachers trained has systematically grown from 28 in 1967 to 524 by March 1973. These are well qualified to teach Primary School Science (See Table 1).

iii. Primary Schools where Elementary Science is taught. At present, 293 primary schools are actively engaged in the teaching of Primary School Science (See Table 3).

(c) Equipment

Since 1970/71, the Science-In-Service Centres have been regularly stocked with equipment for the training of teachers.

Equipment to the tune of N8, 000 has already been supplied in 1972/73 to the eight zonal centres. Equipment to the tune of N18, 000 has also been ordered for 300 primary schools for 1972/73, bringing this to a total of 450 primary schools (including the 150 schools supplied in 1970/71). (See Appendix XII).

4. FURTHER DEVELOPMENT

(a) Primary School Science Officers: Some of our Primary School Science Inspectors who organise and run the In-Service courses are given opportunity to attend any available Science Seminars or Vacation Courses at our Universities in the country. Through this, they are properly equipped for their work.

(b) Courses: The normal courses (vacation and evening) for the production of more capable primary science teachers continue.

(c) New Elementary Science Syllabus: A new syllabus has been compiled to embrace all primary classes (Classes I-VI) in the teaching of science.

A critique Conference is being convened to examine this syllabus before it is put into use.

APPENDIX XIV

STATE CURRICULUM COMMITTEE MEMBERSHIP

Our Ref. No. INS.CON.169/252.

Ministry of Education,
Inspectorate Division,
Ibadan.

12th September, 1974.

Mr. A.A. Taiwo,
Apartment 5B,
14 Washington Place,
New York, N.Y. 10003.

Dear Mr. Taiwo,

Primary Science Teacher's Guide Class I.

I am directed to thank you very much for your valuable contribution as a member of the State Curriculum Committee. We found you quite pleasant to work with. We look forward to your joining us as soon as you are back in Nigeria.

2. As requested I am forwarding to you a copy of the Teacher's Guide for Primary Class I by separate post.

3. Induction courses were conducted on Zonal basis at Ibadan, Ijebu-Ode, Oshogbo and Akure for a number of primary science teachers and inspectors. In all about 140 teachers attended the course. The materials will be tried in 50 pilot schools in all the ~~form~~ Zonal headquarters: Ibadan, Ijebu-Ode, Oshogbo and Akure in the 1974/75 school year.

4. Some other schools in Ilesha and Ijebu-Ode district will try the materials also.

5. I will certainly keep you informed of the work of the committee.

6. Write back if you can find the time.

Yours faithfully,

Ade Ogunnaike

Ade. Ogunnaike,
for Permanent Secretary.

APPENDIX XV

PAIRED SCORES OF SUBJECTS IN BOTH THE PHYSICAL SCIENCE KNOWLEDGE TEST AND THE PIAGET-LIKE TASKS

Scores of Primary Six Urban Male Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	11	5	41	15	9	81	11	8
2	11	6	42	9	9	82	7	7
3	11	6	43	12	7	83	13	7
4	10	3	44	12	4	84	11	9
5	9	7	45	9	9	85	13	10
6	11	6	46	10	9	86	11	6
7	11	4	47	10	9	87	7	8
8	11	6	48	9	8	88	14	10
9	11	6	49	10	7	89	9	5
10	14	5	50	11	7	90	10	5
11	7	8	51	10	7	91	12	7
12	13	6	52	11	6	92	6	8
13	7	5	53	7	7	93	10	8
14	12	4	54	10	9	94	10	3
15	10	6	55	12	9	95	12	10
16	11	5	56	12	9	96	10	9
17	15	6	57	6	7	97	9	9
18	14	5	58	9	8	98	11	8
19	9	7	59	13	9	99	9	8
20	11	7	60	11	9	100	12	8
21	9	6	61	10	5	101	10	7
22	10	7	62	11	9	102	9	7
23	11	7	63	14	3	103	10	9
24	11	6	64	13	3	104	11	9
25	11	8	65	9	8	105	12	9
26	13	8	66	12	6	106	11	7
27	11	8	67	9	8	107	13	9
28	9	6	68	5	5	108	12	7
29	5	7	69	13	7			
30	10	6	70	14	8			
31	10	7	71	13	5			
32	12	7	72	12	8			
33	13	9	73	7	8			
34	14	9	74	8	6			
35	10	8	75	15	5			
36	8	10	76	9	6			
37	10	8	77	13	7			
38	15	9	78	8	7			
39	6	10	79	9	8			
40	13	10	80	10	7			

Scores of Primary Six Urban Female Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	13	4	41	6	7	81	13	9
2	11	6	42	10	7	82	10	7
3	11	6	43	10	6	83	13	7
4	11	5	44	9	6	84	11	9
5	10	5	45	12	8	85	8	4
6	9	4	46	9	5	86	8	9
7	11	6	47	10	6	87	8	5
8	12	6	48	8	7	88	7	9
9	12	6	49	10	9	89	8	4
10	7	6	50	9	8	90	10	6
11	7	6	51	8	5	91	7	8
12	11	6	52	10	6	92	11	5
13	9	8	53	8	8			
14	11	5	54	6	10			
15	7	7	55	10	7			
16	10	8	56	14	8			
17	11	9	57	12	8			
18	9	5	58	12	9			
19	14	10	59	9	9			
20	9	7	60	10	10			
21	12	6	61	12	10			
22	6	6	62	12	9			
23	9	7	63	11	8			
24	5	8	64	7	8			
25	13	8	65	12	8			
26	9	5	66	6	5			
27	13	9	67	11	7			
28	11	9	68	14	8			
29	11	8	69	12	8			
30	11	7	70	8	8			
31	10	7	71	9	9			
32	8	9	72	8	7			
33	11	8	73	11	8			
34	10	4	74	8	5			
35	8	9	75	11	6			
36	10	9	76	11	9			
37	11	9	77	13	9			
38	12	9	78	10	10			
39	9	7	79	9	7			
40	8	4	80	13	8			

Scores of Primary Five Urban Male Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	8	7	41	9	8
2	5	6	42	11	8
3	9	3	43	9	8
4	8	9	44	7	9
5	11	6	45	6	6
6	8	5	46	5	6
7	6	5	47	6	5
8	8	4	48	4	5
9	9	4	49	9	6
10	13	4	50	8	5
11	11	6	51	8	10
12	8	4	52	13	7
13	6	4	53	7	6
14	6	5	54	5	7
15	7	3	55	3	8
16	8	7	56	6	7
17	4	6	57	7	7
18	6	8	58	9	7
19	10	8	59	8	6
20	9	8	60	9	7
21	7	8	61	6	5
22	9	5	62	5	7
23	8	7	63	8	6
24	10	8	64	7	7
25	9	8	65	7	6
26	7	4	66	10	8
27	7	7	67	11	8
28	10	6	68	8	8
29	8	7	69	6	7
30	7	10	70	8	10
31	11	8	71	11	6
32	13	9	72	5	6
33	8	7	73	5	6
34	9	4	74	11	6
35	7	4	75	9	8
36	10	4	76	13	7
37	9	8	77	5	8
38	5	8	78	11	8
39	7	4	79	5	8
40	5	8	80	12	8

Scores of Primary Five Urban Female Subjects on Science Knowledge Test and Piaget-like Tasks

No.	(A) Scores on Science Test	(B) Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	8	6	45	6	7
2	4	10	46	9	4
3	2	9	47	7	4
4	5	8	48	10	6
5	5	6	49	8	8
6	6	7	50	7	6
7	10	5	51	11	8
8	10	8	52	6	9
9	8	6	53	5	9
10	7	6	54	6	9
11	7	5	55	5	9
12	8	5	56	9	10
13	7	5	57	9	9
14	15	10	58	8	9
15	6	3	59	10	9
16	6	6	60	10	9
17	9	4	61	9	8
18	12	6	62	11	8
19	5	4	63	4	8
20	10	8	64	4	8
21	11	8	65	3	9
22	10	8	66	3	10
23	11	8	67	5	10
24	9	8	68	7	6
25	5	6	69	10	9
26	8	4	70	12	6
27	9	8	71	6	6
28	11	8	72	12	8
29	7	8	73	10	6
30	9	7	74	12	8
31	8	10	75	7	5
32	7	9	76	9	4
33	9	8	77	14	9
34	12	7	78	4	8
35	11	7	79	8	5
36	8	6	80	8	6
37	6	6	81	6	4
38	5	8	82	6	7
39	8	8	83	11	8
40	6	5	84	12	8
41	6	5	85	9	8
42	6	8	86	7	6
43	11	6	87	5	8
44	6	6	88	6	6

Scores of Primary Four Urban Male Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	8	4	41	6	5
2	7	5	42	6	5
3	7	6	43	6	5
4	8	7	44	9	6
5	4	4	45	9	5
6	4	4	46	11	7
7	10	7	47	3	7
8	8	7	48	9	7
9	6	6	49	8	4
10	12	7	50	6	4
11	9	8	51	7	6
12	8	8	52	9	7
13	7	8	53	6	6
14	6	6	54	7	8
15	9	5	55	5	9
16	7	9	56	5	9
17	9	9	57	8	6
18	8	9	58	6	6
19	6	9	59	10	7
20	7	8	60	4	4
21	10	7	61	6	3
22	9	6	62	6	6
23	5	8	63	9	6
24	8	8	64	5	4
25	4	7	65	7	5
26	6	9	66	8	7
27	7	9	67	10	7
28	6	7	68	8	4
29	4	8	69	9	6
30	9	8	70	4	4
31	9	8	71	9	5
32	5	9	72	10	6
33	8	9	73	3	6
34	9	8	74	6	7
35	6	9	75	10	7
36	7	7	76	7	6
37	3	4	77	9	9
38	5	6	78	11	9
39	10	6	79	5	5
40	9	5	80	4	4

Scores on Primary Four Urban Female Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	9	6	41	8	5
2	2	7	42	5	7
3	6	6	43	8	4
4	8	7	44	6	4
5	8	6	45	8	9
6	7	4	46	7	9
7	6	8	47	3	8
8	6	7	48	4	9
9	11	6	49	7	8
10	8	7	50	4	10
11	9	6	51	7	7
12	7	9	52	7	7
13	6	8	53	6	6
14	8	4	54	3	7
15	9	4	55	10	7
16	4	7	56	8	9
17	4	4	57	7	9
18	9	5	58	4	6
19	4	4	59	4	8
20	11	5	60	8	9
21	9	5	61	10	6
22	9	7	62	6	6
23	5	7	63	9	6
24	5	4	64	10	9
25	3	8	65	8	7
26	5	7	66	7	8
27	3	7	67	4	9
28	7	7	68	4	7
29	8	7	69	6	8
30	9	7	70	8	6
31	8	6	71	9	7
32	9	7	72	10	9
33	4	8	73	8	7
34	4	6	74	7	7
35	11	7	75	5	7
36	6	6	76	4	4
37	8	7	77	7	7
38	9	9			
39	6	7			
40	2	4			

Scores of Primary Six Non-urban Male Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	8	3	42	11	4
2	11	3	43	7	7
3	8	5	44	5	8
4	7	9	45	7	8
5	6	9	46	9	6
6	10	3	47	8	6
7	8	6	48	8	6
8	8	6	49	10	9
9	10	9	50	10	8
10	6	6	51	9	6
11	4	9	52	9	6
12	5	8	53	7	7
13	8	7	54	12	6
14	6	8	55	8	8
15	7	6	56	13	9
16	12	8	57	9	4
17	6	7	58	8	4
18	10	8	59	8	5
19	11	7	60	9	6
20	7	5	61	8	6
21	8	7	62	11	7
22	8	6	63	8	5
23	5	8	64	9	7
24	9	7	65	10	8
25	11	7	66	11	9
26	4	7	67	9	10
27	10	6	68	12	10
28	7	6	69	9	10
29	11	5	70	12	10
30	12	6	71	12	8
31	7	9	72	10	7
32	8	7	73	9	7
33	7	8	74	11	3
34	10	7	75	9	7
35	7	4	76	10	5
36	8	4	77	6	6
37	11	8	78	10	9
38	12	6	79	9	6
39	4	10	80	10	6
40	5	8	81	10	7
41	9	9			

Scores of Primary Six Non-urban Female Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	7	9	41	9	8
2	7	5	42	7	7
3	7	4	43	7	8
4	7	4	44	6	6
5	7	9	45	10	6
6	7	6	46	9	9
7	9	3	47	9	7
8	7	3	48	7	9
9	8	4	49	8	4
10	6	7	50	4	7
11	5	8	51	7	6
12	10	6	52	7	5
13	7	4	53	6	8
14	5	5	54	7	4
15	8	6	55	10	6
16	5	8	56	12	8
17	5	7	57	8	8
18	8	8	58	12	10
19	6	9	59	8	6
20	9	9	60	7	10
21	6	7	61	11	9
22	10	5	62	6	9
23	6	7	63	8	6
24	7	7	64	12	7
25	5	8	65	8	8
26	6	10	66	9	7
27	7	6	67	9	9
28	12	5	68	12	9
29	4	7	69	10	6
30	6	6	70	5	8
31	4	7	71	10	5
32	9	7			
33	7	10			
34	12	8			
35	6	8			
36	6	8			
37	12	10			
38	9	10			
39	11	9			
40	9	7			

Scores of Primary Five Non-Urban Male Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	4	5	41	4	7	81	7	6
2	6	5	42	10	6	82	10	8
3	4	6	43	6	4	83	10	7
4	5	7	44	4	5	84	5	7
5	5	6	45	10	5	85	7	8
6	6	7	46	4	5	86	10	7
7	4	7	47	5	6	87	12	8
8	5	8	48	10	7	88	10	6
9	3	9	49	9	6	89	3	8
10	4	6	50	9	4	90	4	8
11	6	7	51	4	7	91	3	4
12	5	6	52	6	7	92	6	6
13	2	6	53	5	7			
14	4	4	54	8	10			
15	7	6	55	5	6			
16	3	6	56	8	7			
17	6	5	57	6	7			
18	6	4	58	9	6			
19	3	2	59	5	8			
20	9	4	60	11	8			
21	6	4	61	7	8			
22	6	7	62	8	7			
23	6	7	63	10	8			
24	7	6	64	8	8			
25	7	8	65	5	9			
26	6	6	66	9	7			
27	9	8	67	5	6			
28	6	7	68	6	6			
29	8	6	69	4	8			
30	9	7	70	7	6			
31	9	7	71	9	8			
32	11	7	72	8	8			
33	9	7	73	11	10			
34	3	8	74	6	7			
35	7	7	75	8	8			
36	5	4	76	10	8			
37	4	6	77	10	7			
38	7	7	78	8	7			
39	8	7	79	8	7			
40	9	6	80	4	5			

Scores of Primary Five Non-urban Female Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	4	5	41	6	4
2	6	5	42	7	4
3	3	7	43	5	5
4	4	5	44	4	7
5	7	6	45	7	8
6	4	5	46	7	8
7	6	5	47	8	6
8	7	6	48	6	4
9	11	6	49	6	5
10	11	4	50	11	5
11	6	5	51	8	6
12	4	5	52	11	6
13	5	5	53	6	5
14	7	6	54	9	4
15	6	7	55	6	4
16	7	8	56	8	5
17	5	9	57	8	6
18	5	8	58	8	6
19	7	7	59	7	6
20	11	8	60	6	5
21	10	6	61	5	5
22	3	6	62	3	8
23	4	6	63	5	7
24	9	7	64	4	7
25	8	7	65	9	8
26	7	6	66	6	5
27	9	7	67	4	8
28	6	7	68	9	9
29	9	7	69	7	9
30	6	7	70	7	5
31	10	6	71	8	7
32	6	5	72	6	6
33	8	7	73	9	7
34	7	7	74	9	9
35	4	5	75	9	8
36	4	7	76	4	8
37	3	8	77	4	7
38	13	9	78	4	5
39	4	7	79	6	5
40	11	6	80	7	6

Scores of Primary Four Non-urban Male Subjects on Science Knowledge Test and Piaget-like Tasks

No.	(A) Scores on Science Test	(B) Scores on Piaget's Test	No.	(A) Scores on Science Test	(B) Scores on Piaget's Tasks
1	3	5	41	9	7
2	3	5	42	6	4
3	3	6	43	5	3
4	5	5	44	6	5
5	5	5	45	4	5
6	6	8	46	6	5
7	6	6	47	10	3
8	7	9	48	8	4
9	3	4	49	4	8
10	4	4	50	5	8
11	4	5	51	5	6
12	6	6	52	9	5
13	9	8	53	10	7
14	5	8	54	8	7
15	6	5	55	6	6
16	2	1	56	5	8
17	4	6	57	7	4
18	5	6	58	5	5
19	8	9	59	9	7
20	5	5	60	5	5
21	3	8	61	7	9
22	4	8	62	9	8
23	4	7	63	8	9
24	5	7	64	7	6
25	4	7	65	7	6
26	6	7			
27	4	6			
28	8	6			
29	8	6			
30	6	8			
31	5	6			
32	7	6			
33	5	4			
34	6	8			
35	7	6			
36	6	7			
37	8	10			
38	3	7			
39	5	8			
40	4	7			

Scores of Primary Four Non-urban Female Subjects on Science Knowledge Test and Piaget-like Tasks

No.	Scores on Science Test	Scores on Piaget's Tasks	No.	Scores on Science Test	Scores on Piaget's Tasks
1	5	3	42	5	7
2	5	3	43	6	6
3	6	3	44	6	6
4	3	2	45	5	7
5	3	4	46	5	7
6	7	5	47	8	5
7	6	3	48	7	3
8	4	4	49	8	11
9	7	8	50	8	3
10	5	7	51	3	7
11	5	7	52	8	5
12	7	7	53	8	8
13	6	6	54	8	9
14	9	4	55	9	9
15	5	6	56	7	11
16	9	6	57	7	10
17	7	3	58	6	10
18	8	4	59	6	10
19	6	8	60	4	5
20	7	6	61	7	5
21	7	11	62	8	5
22	6	2	63	8	5
23	6	3	64	9	4
24	6	6	65	8	4
25	4	5			
26	7	3			
27	6	6			
28	6	6			
29	7	6			
30	6	4			
31	6	5			
32	9	5			
33	7	7			
34	5	7			
35	4	6			
36	5	8			
37	6	4			
38	5	3			
39	6	4			
40	3	6			
41	5	6			

APPENDIX XVI

FREQUENCY DISTRIBUTION PROFILE OF SCORES OF THE ENTIRE SUBJECTS ON THE PHYSICAL SCIENCE KNOWLEDGE TEST BY CLASS, SEX AND GEOGRAPHICAL LOCATION.

FREQUENCY OF CHOICES OF PRIMARY SIX MALE URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	99	91.6	6	5.6	3	2.8	0	0.0	a
2	6	5.6	100	92.5	0	0.0	1	0.9	b
3	6	5.6	5	4.6	78	72.5	0	0.0	d
4	2	1.9	20	19.0	5	4.6	65	60.0	e
5	13	12.1	15	13.9	60	55.5	8	7.4	d
6	3	2.8	19	17.6	64	59.2	12	11.1	d
7	73	67.5	26	24.0	6	5.6	3	2.8	a
8	4	3.8	6	5.6	58	53.6	21	19.4	d
9	20	19.0	2	1.9	6	5.6	65	60.0	e
10	25	23.2	46	42.6	15	13.9	7	6.7	b
11	31	28.8	15	13.9	25	23.2	11	10.2	d
12	43	39.8	53	49.0	2	1.9	3	2.8	b
13	12	11.1	73	67.6	7	6.7	5	4.6	b
14	35	32.4	12	11.1	31	28.8	18	16.7	d
15	42	39.0	50	46.0	12	11.1	4	3.8	b
16	38	35.2	32	29.6	10	9.3	26	24.0	a

FREQUENCY OF CHOICES OF PRIMARY SIX FEMALE URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	78	84.9	1	1.1	2	2.2	0	0.0	a
2	5	5.4	75	81.5	0	0.0	0	0.0	b
3	2	2.2	1	1.1	68	74.0	4	4.4	d
4	4	4.4	12	13.0	7	7.6	38	41.4	e
5	14	15.2	6	6.5	42	45.6	4	4.4	d
6	7	7.6	6	6.5	43	46.6	7	7.6	d
7	46	50.0	18	19.6	5	5.4	3	3.3	a
8	4	4.4	4	4.4	46	50.0	16	17.4	d
9	20	21.6	2	2.2	1	1.1	39	42.4	e
10	19	20.6	36	39.2	10	10.8	11	11.9	b
11	28	30.4	15	16.4	20	21.6	6	6.5	d
12	25	27.2	31	33.8	0	0.0	7	7.6	b
13	13	14.1	41	44.5	9	9.8	6	6.5	b
14	31	33.8	15	16.2	12	13.0	9	9.8	d
15	32	34.8	18	19.6	13	14.1	6	6.5	b
16	31	33.8	18	19.6	3	3.3	22	23.8	a

FREQUENCY OF CHOICES OF PRIMARY FIVE MALE URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	65	81.2	9	11.3	0	0.0	3	3.8	a
2	10	12.5	61	76.0	2	2.5	2	2.5	b
3	4	5.0	6	7.6	62	77.5	4	5.0	d
4	9	11.0	23	28.0	9	11.3	30	37.5	e
5	18	22.6	20	25.0	38	47.5	2	2.5	d
6	14	17.5	17	21.2	39	48.8	10	12.5	d
7	47	58.8	25	31.2	2	2.5	5	6.3	a
8	5	6.3	16	20.0	39	48.8	20	25.0	d
9	28	35.0	7	7.6	6	7.6	38	47.5	e
10	27	33.8	25	31.2	14	17.5	9	11.3	b
11	20	25.0	20	25.0	22	27.4	6	7.6	d
12	40	50.0	25	31.2	3	3.8	10	12.5	b
13	18	22.6	49	61.4	4	5.0	6	7.6	b
14	42	52.5	11	13.7	12	15.2	7	8.8	d
15	36	45.0	16	20.0	9	11.3	15	18.9	b
16	22	27.4	27	33.8	4	5.0	26	32.3	a

FREQUENCY OF CHOICES OF PRIMARY FIVE FEMALE URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	74	84.0	5	5.7	5	5.7	0	0.0	a
2	5	5.7	77	87.5	1	1.1	1	1.1	b
3	9	10.2	6	6.8	71	88.6	2	2.2	d
4	6	6.8	28	31.8	9	10.2	39	44.2	e
5	15	17.1	15	17.1	50	56.8	7	7.9	d
6	15	17.1	12	13.6	40	45.5	21	24.0	d
7	52	59.0	24	27.2	10	11.4	5	5.7	a
8	3	3.4	16	18.2	41	46.5	26	29.6	d
9	30	34.0	8	9.1	5	5.7	46	52.2	e
10	32	36.4	34	38.6	13	14.8	11	12.5	b
11	28	31.8	21	23.9	26	29.6	11	12.5	d
12	40	45.5	35	39.7	7	7.9	4	4.4	b
13	16	18.2	52	59.0	9	10.2	13	14.7	b
14	40	45.5	14	15.9	22	25.0	9	10.2	d
15	51	58.0	16	18.2	12	13.6	8	9.1	b
16	19	21.6	37	42.0	5	5.7	28	31.8	a

FREQUENCY OF CHOICES OF PRIMARY FOUR MALE URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question	" " choice		"b" choice		"d" choice		"e" choice		Correct
No.	Freq. No.	%	Freq. No.	%	Freq. No.	%	Freq. No.	%	Choice
1	65	81.2	6	7.6	2	2.5	0	0.0	a
2	5	6.3	58	72.5	1	1.3	3	3.8	b
3	6	7.6	11	13.7	43	53.5	3	3.8	d
4	15	18.9	18	22.6	17	21.2	24	30.0	e
5	17	21.2	5	6.3	34	42.5	9	11.3	d
6	11	13.7	8	10.0	33	41.4	9	11.3	d
7	29	36.2	24	30.0	5	6.3	11	13.7	a
8	9	11.3	7	8.8	29	36.2	16	20.0	d
9	22	27.4	6	7.6	6	7.6	26	32.4	e
10	30	37.5	15	18.9	11	13.7	8	10.0	b
11	21	26.2	15	18.9	13	16.2	10	12.5	d
12	18	22.6	30	37.5	7	8.8	4	5.0	b
13	16	20.0	29	36.2	11	13.7	2	2.5	b
14	37	46.0	12	15.2	7	8.8	9	11.3	d
15	30	37.5	12	15.2	8	10.0	11	13.7	b
16	13	16.2	27	33.8	4	15.0	24	30.0	a

FREQUENCY OF CHOICES OF PRIMARY FOUR FEMALE URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	53	67.0	4	5.2	4	5.2	0	0.0	a
2	5	6.3	50	63.2	1	1.3	3	3.9	b
3	8	10.1	5	6.3	41	52.0	3	3.7	d
4	11	13.8	24	30.4	4	5.2	17	21.6	e
5	18	23.2	6	7.8	29	37.7	3	3.0	d
6	13	16.5	14	17.7	20	25.2	8	10.1	d
7	27	34.2	21	26.6	7	8.8	5	6.3	a
8	13	16.5	10	12.6	21	26.6	13	16.5	d
9	21	26.6	7	8.8	5	6.3	25	31.6	e
10	35	44.4	11	13.8	7	8.8	6	7.8	b
11	29	37.7	11	13.8	14	17.7	1	1.3	d
12	19	24.0	23	29.0	6	7.8	4	5.2	b
13	15	19.0	29	37.7	9	11.6	4	5.2	b
14	32	40.4	10	12.6	11	13.8	3	3.9	d
15	32	40.4	9	11.6	5	6.5	10	12.6	b
16	14	17.7	17	21.6	8	10.1	20	25.2	a

FREQUENCY OF CHOICES OF PRIMARY SIX MALE NON-URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	63	77.8	7	8.6	1	1.2	6	7.4	a
2	6	7.4	71	87.5	2	2.4	0	0.0	b
3	8	9.9	6	7.4	58	71.5	5	6.2	d
4	6	7.4	21	26.0	3	3.6	39	48.1	e
5	22	27.2	7	8.6	44	54.3	10	12.3	d
6	8	9.9	10	12.3	40	49.2	12	14.9	d
7	48	59.4	12	14.9	9	11.1	6	7.4	a
8	8	9.9	12	14.9	38	47.0	16	19.8	d
9	18	22.2	5	6.2	5	6.2	40	49.2	e
10	22	27.2	20	24.6	7	8.6	7	8.6	b
11	24	29.8	12	14.9	16	19.8	9	11.1	d
12	29	35.8	23	29.4	4	4.9	10	12.3	b
13	8	9.9	45	55.5	3	3.7	5	6.2	b
14	35	43.1	11	13.6	13	16.0	16	19.8	d
15	36	44.5	22	27.2	7	8.6	3	3.7	b
16	23	29.4	32	39.4	3	3.7	20	24.6	a

FREQUENCY OF CHOICES OF PRIMARY SIX FEMALE NON-URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	%	"b" choice Freq. No.	%	"d" choice Freq. No.	%	"e" choice Freq. No.	%	Correct Choice
1	55	77.5	9	12.6	5	7.0	0	0.0	a
2	15	21.0	56	79.0	0	0.0	0	0.0	b
3	16	22.4	5	7.0	44	62.0	5	7.0	d
4	17	23.8	16	22.6	14	19.6	24	33.6	e
5	15	18.5	8	11.2	37	52.0	4	5.6	d
6	11	15.5	13	32.4	35	49.4	8	12.2	d
7	42	59.2	17	24.0	8	11.2	4	5.6	a
8	10	14.0	10	14.0	32	44.8	14	19.6	d
9	22	31.0	2	2.8	2	2.8	39	48.1	e
10	29	40.8	22	31.0	9	12.6	10	14.0	b
11	17	24.0	20	28.0	23	32.4	9	12.6	d
12	42	59.0	17	24.0	7	9.8	5	7.0	b
13	19	26.8	35	46.5	7	9.8	9	12.6	b
14	35	49.2	8	11.2	17	24.0	11	15.5	d
15	29	40.8	25	35.2	7	9.8	7	9.8	b
16	15	21.0	26	36.7	9	12.6	22	31.0	a

FREQUENCY OF CHOICES OF PRIMARY FIVE MALE NON-URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice		"b" choice		"d" choice		"e" choice		Correct Choice
	Freq. No.	%	Freq. No.	%	Freq. No.	%	Freq. No.	%	
1	69	75.0	9	9.8	3	3.3	4	4.4	a
2	12	13.0	68	74.0	1	1.1	3	3.3	b
3	18	19.6	9	9.8	44	47.5	6	6.5	d
4	17	18.5	18	19.6	6	6.5	38	41.2	e
5	23	25.0	10	10.8	41	44.5	9	9.8	d
6	19	20.6	14	15.2	22	23.8	23	25.0	d
7	41	44.5	18	19.6	11	11.9	3	3.3	a
8	22	23.8	15	16.4	16	17.4	18	9.6	d
9	23	25.0	9	9.8	33	9.8	35	35.8	e
10	28	30.4	30	32.6	3	3.3	8	8.8	b
11	20	21.6	20	21.6	21	22.8	8	8.8	d
12	43	46.6	12	13.0	4	4.4	7	7.6	b
13	25	27.2	30	32.6	11	11.9	6	6.5	b
14	50	54.4	7	7.6	10	10.8	7	7.6	d
15	31	33.8	25	25.0	10	10.8	11	11.9	b
16	22	23.8	29	31.6	8	8.8	22	23.8	a

FREQUENCY OF CHOICES OF PRIMARY FIVE FEMALE NON-URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice Freq. No.	"a" choice %	"b" choice Freq. No.	"b" choice %	"d" choice Freq. No.	"d" choice %	"e" choice Freq. No.	"e" choice %	Correct Choice
1	60	75.0	6	7.6	6	7.6	3	3.8	a
2	12	15.2	64	80.0	0	0.0	2	2.5	b
3	17	21.2	17	21.2	39	48.8	2	2.5	d
4	14	17.6	20	25.0	8	10.0	34	42.5	e
5	20	25.0	13	16.2	32	40.0	16	20.0	d
6	14	17.6	15	18.9	21	26.2	24	30.0	d
7	39	48.8	21	26.2	11	13.7	7	8.8	a
8	19	23.8	16	20.0	27	33.8	14	17.5	d
9	30	37.5	11	13.7	7	8.8	30	37.5	e
10	31	38.8	33	41.4	4	5.0	7	8.8	b
11	32	40.0	11	13.7	15	18.9	11	13.7	d
12	33	41.4	26	32.4	11	13.7	4	5.0	b
13	24	30.0	32	40.0	8	10.0	7	8.8	b
14	55	68.5	3	3.8	13	16.2	5	6.3	d
15	33	41.4	15	18.9	12	15.2	13	16.2	b
16	21	26.2	25	31.2	9	11.3	21	26.2	a

FREQUENCY OF CHOICES OF PRIMARY FOUR MALE NON-URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice		"b" choice		"d" choice		"e" choice		Correct Choice
	Freq. No.	%	Freq. No.	%	Freq. No.	%	Freq. No.	%	
1	35	53.9	15	23.1	9	13.9	1	1.5	a
2	8	12.3	46	70.8	1	1.5	2	3.1	b
3	17	26.2	13	20.0	22	33.8	3	4.6	d
4	10	15.4	13	20.0	6	9.2	27	41.5	e
5	20	30.8	8	12.3	18	27.8	5	7.7	d
6	7	10.8	19	29.2	16	24.6	11	16.9	d
7	23	35.4	18	27.8	14	21.6	3	4.6	a
8	13	20.0	15	23.1	8	9.2	12	18.4	d
9	19	29.2	6	9.2	12	18.4	10	15.4	e
10	23	35.4	15	23.1	5	7.7	3	4.6	b
11	15	23.1	18	27.8	10	15.4	9	13.9	d
12	15	23.1	13	20.0	9	13.9	9	13.9	b
13	13	20.0	24	36.8	8	12.3	2	3.1	b
14	27	41.5	10	15.4	4	6.2	4	6.2	d
15	26	40.0	11	16.9	7	10.8	8	12.3	b
16	11	16.9	18	27.8	11	16.9	13	20.0	a

FREQUENCY OF CHOICE OF PRIMARY FOUR FEMALE NON-URBAN SUBJECTS ON SCIENCE KNOWLEDGE TEST

Question No.	"a" choice		"b" choice		"d" choice		"e" choice		Correct Choice
	Freq. No.	%	Freq. No.	%	Freq. No.	%	Freq. No.	%	
1	40	61.6	19	29.1	4	6.2	2	3.1	a
2	20	30.8	38	58.2	4	6.2	3	4.6	b
3	20	30.8	15	23.1	22	33.8	2	3.1	d
4	22	33.8	10	15.4	15	23.1	19	29.1	e
5	12	18.4	10	15.4	25	38.4	9	13.9	d
6	20	30.8	16	24.6	19	29.1	11	16.9	d
7	35	53.9	12	18.4	11	16.9	7	10.8	a
8	16	24.6	18	27.8	18	27.8	10	15.4	d
9	21	31.3	6	9.2	10	15.4	27	41.5	e
10	31	47.6	15	23.1	10	15.4	8	12.3	b
11	15	23.1	16	24.6	9	13.9	7	10.8	d
12	26	40.0	18	27.8	8	12.3	8	12.3	b
13	19	29.2	29	44.5	5	7.7	6	9.2	b
14	37	57.0	6	9.2	12	18.4	3	4.6	d
15	21	32.3	22	33.8	9	13.9	9	13.9	b
16	19	29.2	28	43.2	4	6.2	13	20.0	a

APPENDIX XVII

FREQUENCY PROFILES OF CORRECT RESPONSES OF THE SAMPLE TO THE QUESTIONS DEALING WITH PIAGET-LIKE TASKS

FREQUENCY DISTRIBUTION OF CORRECT REPONSES OF ALL THE SUBJECTS OF THE STUDY ON PIAGET-LIKE TASKS

	Urban Subjects						Non-Urban Subjects					
	Primary Six		Primary Five		Primary Four		Primary Six		Primary Five		Primary Four	
No.	Boys %	Girls %	Boys %	Girls %	Boys %	Girls %	Boys %	Girls %	Boys %	Girls %	Boys %	Girls %
1.	16.1	38.0	30.0	35.2	16.2	6.5	27.2	28.2	15.2	15.9	18.5	26.2
2.	31.1	50.0	32.5	33.0	31.2	22.0	44.4	29.6	19.6	17.0	18.5	18.5
3.	94.5	100.0	93.6	97.6	83.6	82.0	90.0	90.2	89.0	83.0	80.0	87.6
4.	78.5	76.1	48.6	70.3	55.0	68.6	71.5	71.8	78.2	58.0	54.0	60.0
5.	78.5	82.5	55.0	67.0	72.5	75.5	70.4	70.5	67.5	58.0	52.2	67.6
6.	95.4	99.0	93.6	95.5	95.0	84.5	87.5	94.4	96.8	88.6	72.4	100.00
7.	100.0	100.0	83.6	80.0	80.0	85.5	95.0	100.0	93.5	88.6	80.0	87.5
8.	93.5	86.0	58.6	63.6	63.6	59.6	69.0	81.6	70.5	54.5	54.0	52.2
9.	76.8	75.0	52.5	70.0	70.0	41.5	68.0	67.5	63.0	54.5	61.5	60.0
10.	99.1	99.0	97.5	93.6	93.6	84.5	100.0	95.6	96.8	85.2	87.5	97.0

FREQUENCY DISTRIBUTION OF CORRECT RESPONSES OF URBAN SUBJECTS ON PIAGET-LIKE TASKS

Ques. No.	Primary Six Class Boys Freq. No.	%	Girls Freq. No.	%	Primary Five Class Boys Freq. No.	%	Girls Freq. No.	%	Primary Four Class Boys Freq. No.	%	Girls Freq. No.	%
1.	29	16.1	35	38.0	24	30.0	31	35.2	13	16.2	5	6.5
2.	56	31.1	46	50.0	26	32.5	29	33.0	25	31.2	17	22.0
3.	102	94.5	92	100.0	75	93.6	86	97.6	67	83.6	63	82.0
4.	85	78.5	70	76.1	39	48.6	62	70.3	52	55.0	53	68.6
5.	85	78.5	76	82.5	52	55.0	59	67.0	58	72.5	58	75.5
6.	103	95.4	91	99.0	75	93.6	84	95.5	76	95.0	65	84.5
7.	108	100.0	92	100.0	67	83.6	87	99.0	64	80.0	65	85.5
8.	101	93.5	79	86.0	47	58.6	70	79.5	51	63.6	46	59.6
9.	83	76.8	69	75.0	46	52.5	52	59.0	56	70.0	32	41.5
10.	107	99.1	91	99.0	78	97.5	88	100.0	75	93.6	65	84.5

FREQUENCY DISTRIBUTION OF CORRECT RESPONSES OF NON-URBAN SUBJECTS ON PIAGET-LIKE TASKS

Ques. No.	Primary Six Class Boys Freq. No.	%	Primary Six Class Girls Freq. No.	%	Primary Five Class Boys Freq. No.	%	Primary Five Class Girls Freq. No.	%	Primary Four Class Boys Freq. No.	%	Primary Four Class Girls Freq. No.	%
1.	22	27.2	20	28.2	14	15.2	14	15.9	12	18.5	17	26.2
2.	36	44.4	21	29.6	18	19.6	15	17.0	12	18.5	12	18.5
3.	73	90.0	64	90.2	82	89.0	73	83.0	52	80.0	57	87.6
4.	58	71.5	51	71.8	72	78.2	51	58.0	35	54.0	39	60.0
5.	57	70.4	50	70.5	62	67.5	51	58.0	34	52.2	44	67.6
6.	71	87.5	67	94.4	89	96.8	78	88.6	47	72.4	65	100.0
7.	77	95.0	71	100.0	86	93.5	78	88.6	52	80.0	57	87.5
8.	56	69.0	58	81.6	65	70.5	48	54.5	35	54.0	34	52.2
9.	55	68.0	48	67.5	58	63.0	48	54.5	40	61.5	39	60.0
10.	81	100.0	68	95.6	89	96.8	75	85.2	57	87.5	63	97.0

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