THE EFFECTS OF MODES OF PRESENTATION ON THE STABILITY OF CHEMISTRY STUDENTS COGNITIVE STYLES

BY

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D E C L A R A T I O N

I hereby certify that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated by quotation marks or indentation and the sources of information are specifically acknowledged by means of references.

MERCY FUNKE OGUNSOLA BANDELE

CERTIFICATION

This thesis, entitled "The Effects of Modes of Presentation on the Stability of Chemistry Students Cognitive Style", by M.F. Ogunsola Bandele meets the regulations governing the award of the degree of Doctor of Philosophy (Curriculum and Instruction in Science) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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D E D I C A T I O N

This work is dedicated

to my Dad

(He knows why)

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F U N K E.

A B S T R A C T

The existence of the construct of cognitive style has been well documented in the literature. Its orientation and distribution among subjects of different cultural settings have been the focus of most published reports. The efforts at classification however have limited educational value unless they can be employed to improve the teaching - learning processes.

The purposes of the present study were to re-confirm the distribution of cognitive style among a General class chemistry students (of GCE A Level equivalents), validate another self-designed instrument (the DIT) which may be used to assess the distribution of subjects on the four dimensional model proposed by Heath, identify the teachers perception of their students cognitive styles so as to draw inferences on the possible influence of the teachers perception of students cognitive styles on the students own cognitive styles, and finally determine the effectiveness of an attempt to shift students cognitive styles through teaching.

A total of three hypotheses on the distribution of cognitive styles among subjects, the effect of teachers perception of students cognitive styles on students own cognitive styles, and the effectiveness of the experimental treatment were tested.

In the experimental part of the study, the Solomon 4-way (Pre-and Post-test Control Group) design was employed, with a total of 69 students and 3 chemistry teachers. The non-parametric statistics of X^2 and Mann-Whitney U-tests were used for the analyses.
The results showed that :

1. The College of Agriculture students have a comparable pattern of cognitive styles with their SBS/ABU counterparts, showing a greater preference for recall style than any other style. The relative proportions of the distributions however differed with the College of Agriculture students exhibiting greater proportion of Application and Questioning styles than SBS/ABU students,
2. Teachers can influence their students cognitive styles, for the students cognitive styles tend to correlate significantly with the teachers perception of their students cognitive styles.
3. It is possible to shift students cognitive styles from predominantly recall to a more even distribution of cognitive style on the 4 - mode model of Heath using an instructional strategy that emphasizes questioning.
4. Between the criterion measures, the Heaths model proved to be more consistent than the D..I.T, in demonstrating a shift in cognitive style from Recall to Questioning.

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ABBREVIATIONS AND DEFINITIONS

In the course of this study, some words have been abbreviated because of their frequent use, and some terms have been used in special ways. The abbreviated words and specially defined terms are listed below:-

ABBREVIATIONS

A.B.U.	Ahmadu Bello University, Zaria, Nigeria.
B.A.T.	Biology Achievement Test
B.C.P.I.	Biology Cognitive Preference Inventory.
B.C.P.T.	Biology Cognitive Preference Test.
C.B.A.	Chemical Bond Approach
C.E.S.A.C.	Comparative Education Study and Adaptation Centre.
C.P.E.-II	Cognitive Preference Examination II
C.P.E.C.	Cognitive Preference Examination Chemistry.
C.P.T.	Cognitive Preference Test.
C.C.P.T.	Combined Cognitive Preference Test
C.S.	Cognitive Styles
D.I.T.	Defining Issue Test
E.S.S.	Educational Set Scale
H.S.C.	High School Certificate
N.S.S.S.P.	Nigerian Secondary Schools Science Project.
O.C.S.T.	Ogunsola Cognitive Style Test
R.P. Q.A.	Heath's Conception/Model of Cognitive Preference (Recall, Principles, Questioning and Application).

P.G.D.E.	Post Graduate Diploma in Education
S.B.S.	School of Basic Studies
S.C.A.T.	School and College Ability Test.
S.T.A.N.	Science Teachers Association of Nigeria.
S.P.O.T.S.	Students Perception of Teachers Styles.
W.A.S.C.	West African School Certificate.
N.E.T.C.	National Educational Technology Centre.

DEFINITION OF KEY TERMS:

1. Cognitive Styles.

This has been defined as individual variation in modes of perceiving, remembering and thinking, or as distinctive ways of apprehending, storing, transforming and utilizing information (Kogan, 1971).

2. Cognitive Preference:

This is the internal unseen mode of an individual that leads to exhibiting the cognitive style which can be seen externally, i.e. it is the underlying internal factor in the exhibition of a cognitive style.

3. Direct Observational Studies:

These are studies involving the observations of classrooms in which the observer(s) or his substitute must be physically present.

4. Indirect Observational Studies:

These are studies which rely on the imaginations and perceptions of teachers who, in this case, are the "observers" of their own students.

5. CESAC: The Comparative Education Study and Adaptation Centre, was established as part of a centralized national effort to evolve a more suitable system of education that is continually adapted and responsive to the nation's economic and social aspiration.

6. Matching Model:

This is the practical application of cognitive styles whereby students are placed together and in the same class with a teacher whose cognitive styles are the same or are closely associated with each other.

7. Educational Set:

This term has been used synonymously with cognitive style (Siegel and Siegel, 1965). It describes the consistent manner in which students respond to scholastic materials which determines the kind of academic material with which he prefers to deal. Three such sets have been identified in the literature, namely: the factual, neutral and conceptual set. The factual set learner is predisposed to learn factual contents. This person is described as one who recalls, in the Heath's model.

The conceptual learner rejects factual acquisition and prefers to learn concepts and principles. This orientation is akin to application, principles and questioning of Heath's model. The neutral set learner is in between.

8. Learning Strategies:

Most British authors prefer to use learning strategies instead of cognitive style. They identified two broad classes; the Holists, who use the global approach and the Serialists who use a localized approach concentrating more on procedures. The serialist may be compared with the learner whose cognitive style is predominantly principle or application in the Heath's model.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

The present study is an outgrowth of a previous study on cognitive styles of chemistry students in S.B.S./A.B.U., Zaria (Ogunsola, 1981). In that study it was found that students had a greater preference for recall than principles, application and questioning. Heath (1964) postulated a 4-mode model of cognitive styles: memorisation and recall (R), learning the underlying principle (P), learning the application (A) and fitting the information, like the jigsaw puzzle into an existing mental schema (structure) through critical questioning (Q).

Heath's approach marked an important step in the field of cognitive style research, for he demonstrated a method of measuring cognitive preferences within the same context as that to which the measurement is to be applied. Using a sample of classes following the Physical Science Study Committee (PSSC) curriculum and a sample of those following conventional curriculum, Heath demonstrated differences between them in terms of cognitive preference, thus inspiring several other researchers by his work.

On the stability of cognitive styles Witken et al (1967) expressed the view that cognitive styles are comparatively stable overtime and to a large degree independent of the nature of the information presented to the learner.

This view has been criticised by Glaser (1970), who argued that it is the teacher who directs and disciplines students thought processes and so influences their cognitive styles.

Several researchers have carried out works which tend to agree or refute the stability of cognitive styles. Among them is Siegel and Siegel (1965a) who both dealt with the consistent manner in which students respond to scholastic material. They defined this manner as "the learner's set (which) determines the kind of academic material with which he prefers to deal". By using an Educational Set Scale (ESS), they were able to differentiate between fact-oriented and concept-oriented students. The scale itself is a forced-choice instrument with thirty-one triads, each containing one factual set, one neutral and one conceptually set components. Students were asked to assume that they had to attend a class in a particular subject and indicate which of the triad of topics presented would interest them most and then the least, by ranking the triads of topics from 1 to 3.

The ESS was shown to be a highly reliable and valid instrument and clearly differentiated students in beginning and upper levels of their programmes Its content covered areas of scholastic content, though its authors made no attempt to examine similarities or differences based on content. However, Williams (1975) argued that since this instrument focused on only one bipolar dimension of cognitive style, it would leave out other aspects of cognitive behaviors.

Siegel and Siegel (1965b) further postulated a broad kind of set with implications for teaching and learning an educational set. This set is presumed to determine the specific kind of content the learner tends to extrapolate from his educational experiences. An educational set is a continuum defined at the poles by predisposition to learn factual content on the one hand and conceptual content on the other. Most persons are educationally set somewhere near the middle of this continuum. According to them, a factually set learner is one who, by definition is predisposed to learn factual contents. He adds units of information to his cognitive structure without being driven to interrelate these elements into any contextual whole. For such a learner, a fact has an integrity of its own. A conceptually set learner is one who, by definition, rejects factual acquisition except as units of information are clustered and interrelated. He prefers to learn concepts and principles. When confronted by a bit of factual information, he either dismisses it as "unimportant" or subsumes it in a broader conceptual framework.

The educational set as measured by ESS probably reflects the learner's cognitive style rather than a more narrow perceptual process. A student placement on factual conceptual set continuum is a "given" with which he enters a course. By the time he is an undergraduate, his educational set can be assessed reliably indicating that this is a stable rather than a transitory variable. Furthermore, an educational set influences the quality of acquisition of various experiences.

These findings suggest at least two problems for investigation with potential significance for structuring educational experiences for the need of the learner.

First, there is the issue of the role of instructional experiences in altering students cognitive styles. Both on the basis of evidence and on intuitive grounds, a defence can be made for attempting to alter students cognitive style in a conceptual direction. Further investigation is needed to determine the impact, if any, of specific kinds of instructional experiences upon the cognitive preference with which the learner confronts these experiences.

A second, presently unresolved issue, concerns the development of cognitive style. Does the learner's general posture toward new material develop prior to or following early school experience? What is its etiology? Since the correlation between set and academic ability is not especially high, one may speculate that cognitive style somehow reflects a pattern of preschool experiences and reinforcement.

In the present study the possibility of shifting students cognitive style in a desired direction is to be examined.

Mark (1967) asserted the equivalence of cognitive style or preference but then went on to use the cognitive preference to evaluate chemistry objectives rather than identify constructs of cognitive styles.

He reported that the CBA was achieving at least one of its objectives and that the cognitive style of the CBA students

seem more tied to conceptual learning than verbal structure. This implies that students are likely to exhibit same cognitive styles as those implied in the curriculum material used. This study inspired Omoifo's (1986) work.

Payette (1967), although derived some inspiration from Heath's study, did not follow Heath's approach to identify cognitive preference. Payette viewed a preference as affective behaviour manifested as a willingness to respond in a consistent way and corresponding to level 2.20 of the Taxonomy of Educational Objectives in the affective domain (Krathwohl et al. 1964).

The format of Payette's test consisted of a number of passages relating to issues in the social sciences. Each passage was followed by four responses, each representing one of four cognitive preferences derived from the taxonomy. Respondents were required to rank the responses in order of their preferences. Payette's major objective was the development of a test. He did not engage in a research which might have thrown some light on the nature of the constructs with which he was working, though he did demonstrate that students being instructed under a special curriculum (the project group), showed greater preference for methodology and principles than the other three (recall, application and questioning) cognitive preferences. However, Payette did not compare these students with others following traditional courses as Heath and Marks had done.

An instrument for the present study is designed using the format of Payette's test. A number of situations relating to issues in chemistry was presented and each

situation was followed by four responses, each corresponding to one of Heath's conception of cognitive preference. This approach, following on Rest (1974). Defining Issue Test (DIT), offers another means of reverifying the cognitive style construct and their distribution among the subjects for the present study.

Several other studies here in Nigeria and elsewhere have demonstrated that there is a significant difference in cognitive style between successful science students and the less successful ones (Kempa and Dube, 1973; Ogunyemi, 1973; Barnette, 1974 and Okebukola, 1984).

All the studies so far considered seem to suggest that the construct and distribution of cognitive styles remain to be confirmed. But even if the pattern of cognitive styles among students had been known, those of the teachers and curriculum materials need to be established and the nature of their association with students cognitive styles must be determined.

It has been suggested that if in fact cognitive preference is a fixed character, then it could be a useful tool in teacher education and selection (Tamir, 1977 and 1982). If the cognitive style of the teachers and students are known, it may be possible to match teachers with a particular style to students of that same style (Hunt, 1970). The identification and effective matching of these styles, if used in addition to the grades derived from the normal cognitive tests, could lead to a more valid and comprehensive characterisation of students overall educational attainment, than results from academic achievement tests alone.

More likely however is that cognitive preference is a learned trait which can be changed by maturity, interactions and experiences. Cognitive preference tests do show in a most convincing manner that not all people prefer to learn in the same way. If one can assume that students learn best in their preferred way, one then has some rather overwhelming evidence for the logic of offering alternative modes of instruction and learning in a classroom. It is hence necessary to try and establish such logical modes that best suit instruction.

In order to get at what goes on in the classroom as regards interactions, interactionists use classroom observation techniques. The approach has been used to describe typical classroom behaviour as a model for teacher preparation.

There are two approaches to classroom observational studies:- the direct and the indirect approaches. With the direct classroom observation studies, the physical presence of an observer in the classroom is of paramount importance. This is the approach that is more commonly used (Medley and Mitzel, 1963; Flanders, 1966; Fischler and Zimmer, 1968; Shuaibu, 1979 and Eggleston, 1983).

However the presence of an observer in the classroom may constitute a barrier to normal classroom teaching and any tranwaction that goes on may not be typical of what goes on when the observer is not there.

Classroom behaviours measured through direct observation studies of the type of Flanders (1966) have been used mainly for verbal interaction in the classroom. This emphasis on verbal interaction appears to be the least appropriate for the typical science classroom engaged in activity teaching and learning. The system is unlikely to pick on these activities.

One way of getting round the problem and criticism is to adopt an indirect approach to the study of classroom settings. An indirect measure of students behaviours through teachers own perception of their students should throw more light on the realities as they exist in a typical science classroom.

Martins (1984) examined student - teachers perceptions of student behaviour in science classrooms of Nigerian Secondary Schools. Rather than use an outside observer, 94 science education students were requested to imagine and describe five typical students in their science classes. This indirect approach to classroom observation provided 5 x 94 (470) observations. The detail of this is reviewed in chapter 2.

Mahuta (1985) replicated Martins work using 137 experienced and practicing teachers from Kaduna State of Nigeria. A total of 5 x 137 (= 685) descriptive data were similarly analysed. Both Martins and Mahuta summarized the main behavioural adjectives of each response and thus derived the following eight polar adjectives in a

rank order: Negative - positive Attitude in Science Work, Negative - Positive Attitude towards Science, Negative - Postive Attitude to Rules and Regulations, Introvert - Extrovert in Personality, Low - High Intelligence, Negative - Positive Attitude to Peer Group and Teachers, Low - High in Creative Ability and Negative - Positive Self-concept. There was a positive (although somewhat low) significant correlations (rs = 0.4 for N = 1155) between the rankings of the two studies.

The outcome of Martin's (1984) and Mahuta's (1985) works suggest that information on the nature of the interaction in the classroom which is normally obtained through secondary sources (i.e. through observers) may not altogether be reliable. Between researchers and classroom teachers, there is a possibility of a misconception of "appropriate behaviour" which engage the attention of teachers and students in the classroom. Any attempt to get at what goes on in the science classroom must minimally consider the teachers perception of that phenomenon. In this study, classroom teachers have been asked to identify the cognitive styles of their students using Martins (1984) approach.

1.2: Statement of the Problem:

The present study is in part an attempt to replicate an earlier study on the prevalent cognitive styles among Chemistry students in S.B.S/A.B.U., Zaria (Ogunsola 1981) and to examine the possibility of shifting students cognitive style in a desired direction through teaching.

It attempts to answer three major questions, namely:-

1. Is the order in cognitive style of the SBS/ABU students expected to be the same as would be found among the College of Agriculture Chemistry students?
2. Is the order of the teachers perception of students cognitive style the same as would be found with the students cognitive style?
3. Can a learner's cognitive style be changed in a desired direction?

In order to demonstrate the possibility of shifting students cognitive style, the comparability of cognitive styles of subjects with about the same background must first be established.

In more specific terms, this investigation is to find out:-

1. the distribution of the General Class Chemistry students cognitive style and to compare it with that of an earlier study of SBS/ABU students;
2. the teachers perception of their students cognitive style;
3. the effects of using two different modes of instruction on students cognitive styles.

1.3 Need for the Study:

Heath (1964), Tamir (1975, 1977) and others have established the existence of the construct of cognitive style, but the orientation and distribution of this style among Nigerian chemistry students and teachers are yet

to be confirmed.

Heath demonstrated a method of measuring cognitive preference within the same context as that to which the measurement is to be applied. The Cognitive Preference Test (CPT) in High School Physics which Heath developed was a novel instrument. It bore the form of a four option multiple choice test, the stem being an item of information or diagram, while each of the four responses following the stem represented one of the cognitive preferences (Recall, Practical Application, Critical Questioning and Principles).

The difference between this test and a conventional multiple choice lay in the fact that all the responses were correct. The students were told that all options were correct and were required to indicate which response they preferred or was most satisfying to them. This test was an experimental instrument only and Heath reported several non-functional items.

Tamir, though used Heath's (1964) model, also employed Kempa and Dube's (1973) graded rating procedure in which each of the four extension statements received a rank, the most appealing was designated as 4 and the least appealing was designated as 1.

The CPT format which has been widely used is bedevilled with the problem of scoring and the stem is often suggestive of the keyed cognitive style.

The Rest (1974) Defining Issue Test (DIT) offers a promising alternative way of re-verifying the existence and the distribution of the cognitive style construct.

The DIT consists of six hypothetical stories and subjects were required to evaluate a set of 12 issues - statements. The subjects rated how important each issue statement was in deciding what ought to be done. This was a recognition task which enabled the subjects to reason. In addition, the subjects were required to rank four most important choices, making objective scoring possible. The use of the DIT model is to be explored in the present study.

The classification of subjects according to cognitive style by itself has a limited value, unless it can be employed to improve teaching and consequently, students learning.

Omoifo (1986) has demonstrated that curriculum materials may have little or no influence on students cognitive style. Omoifo's finding delimits the factors that have the greatest potential to influence students cognitive style.

Hunt (1979) postulated the matching model. The model is predicated on the possibility of teachers influencing students cognitive style. According to Hunt, there can be a complete match of cognitive style between teachers and students or a mismatch. And if there is a match, it would lead to higher achievements.

But the question is, how does one get the empirical data to support the claims that students have really been matched to their teachers on the basis of their cognitive styles?

A classroom observation study technique could be employed. This method however suffers some threats to external validity. Some of the problems of reliability and validity have been expoused by Martins (1984).

Shuaibu and Martins (1984) and Mahuta (1985) have suggested an indirect approach to observation. Instead of observers or their agents visiting the classroom to record events, the teachers perception of students behaviour in their classrooms are recorded. An application of this method should provide evidence to support the nature of the interaction in the classroom.

In the R, P, A, Q model of Heath's conception of cognitive style, some value orientation is implied. It is argued that a science curriculum which emphasizes R and P and little of A and Q is unlikely to produce graduates who are creative and are imbibed with the questioning spirit of scientists. Rather, these later qualities are associated more often with A and Q. If there is an overwhelming evidence that Nigerian students at this level are predominantly recallers, the desirability to help shift their cognitive styles to A and Q becomes self-evident. Moreover, most of the more recent science curricula purport to teach for A and Q

This study is therefore undertaken to:-

a) Re-confirm the distribution of cognitive styles among chemistry students using both the Heath and the Defining Issue Test (D.I.T) models.

b) Identify the teachers perception of their students

cognitive style independently (using Shuaibu and Martins 1984 approach).

c) Examine the possibility of shifting students cognitive styles through teaching.

This last objective could break new grounds in teaching for desired cognitive style.

1.4: BASIC ASSUMPTIONS

1. It is assumed that curriculum material and the other milieux of the school curriculum have little or no effect on the cognitive styles of the users.
2. That teachers can be depended upon for their perception of their students cognitive styles.
3. Cognitive style is presumed to be a construct which is teachable.
4. Every student participating in the cognitive preference tests understands every option under each item so well that he can realistically place the option in a preference order.
5. The degree of variation in the syntax of each item has little or no effect on the preference ranking of subjects.

1.5: HYPOTHESES

The following null hypotheses will be tested in this study.

(i) The cognitive style distribution among the four classes in the experimental design is not significantly different.

(ii) The cognitive style distribution among students is not significantly different from teachers classification (Perception).

(iii) The experimental treatment (the mode of teaching) has no significant effect on the cognitive style distribution of the subjects.

The rejection of the first null hypothesis will amount to the observation that the distribution of subjects cognitive style among the four modes differ significantly. This situation will then be compared by inspection with the findings in the earlier study of SBS/ABU Chemistry Students (Ogunsola 1981).

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1. Introduction

The research literature partaining to cognitive styles stems both from the psychological and the educational field. Since the psychological constructs are not the central concern in the present study, the former field will not be examined fully here. But in summary, it can be said that psychological studies relating cognitive style to such variables as personality, intelligence or academic aptitude have produced inconsistent findings. Agreement, or lack of it, is likely to have been determined by the nature of the measures of the other variables.

If the concept of cognitive style is to prove useful in an educational context, either by contributing to the prediction of success in various disciplines, or to the development of appropriate teaching methods, then it will be necessary to show a relationship between cognitive style dimensions and performance on academic tasks.

If one were to correlate scores on conventional scholastic tests with scores derived from tests of cognitive style, it would be with the rationale that consistent cognitive strategies or preferences evident in one type of context will also manifest themselves in a different type of context.

Thurstone (1944) in his classic study of perception has really encouraged this approach with his statement. "One wonders whether it will be possible eventually to appraise individuals as to some of their intellectual characteristics in terms of tests which do not themselves represent intellectual tasks".

It is clear that the contents of very few of the tests used to measure cognitive styles bear any resemblance to conventional scholastic tasks. Many are derived from studies of perception, for it was largely from attempts to explain individual differences in perception as personality characteristics which led to the investigation of cognitive styles.

If it were proposed, then, that a cognitive style, say field dependence, is associated with an intellectual task, say problem solving in mathematics, then the use of such a test as the Embedded Figure Test would be an indirect way of measuring Cognitive Style involvement in this task. Sticker and Ross (1964) pointed out that "indirect measurement inevitably introduces extraneous sources of variance". It seems to this writer highly desirable to eliminate this source of variance as far as possible, and one way of doing so would be to derive measures of cognitive preferences as they apply to intellectual or scholastic tasks, from the very subject matter with which these tests are concerned. In this study, the test items are to to be derived from chemistry.

The cognitive styles of students and teachers have been extensively investigated elsewhere and very little has been reported in Nigeria.

In this chapter, relevant literature concerning cognitive styles and achievements are reviewed. The chapter is divided into five parts.

(i) The first part deals with the relevant literature on the distribution of science students cognitive styles.

(ii) The second part deals with the cognitive styles implied in curriculum material.

(iii) The third part deals with the teachers cognitive style and the identification of the students cognitive style using the teachers.

(iv) The fourth part deals with the methodological issues and especially the treatment of data.

(v) And the last part deals with the Rest (1974) Defining Issues Test (DIT) approach.

2.2: STUDENTS COGNITIVE STYLE:

Much of the published works have shown that students are distributed in their cognitive styles in a pattern which suggests the influence of teachers cognitive style and the cognitive style implicit in their curriculum materials.

The lead in this direction has already been given by Heath (1964), who defined cognitive preference as "differing modes of attending to the subject matter of a course". Several researchers followed by trying to identify the cognitive styles of the students and find the relationship between cognitive styles and factors such as age, gender, achievement, etc. (Mark 1965; Kempa & Dube, 1973; Ogunyemi, 1973; Barnett, 1974; Ogunsola, 1981; McNaught 1982; Okebukola, 1984).

According to Heath "the interest (in cognitive style) is not in whether the student can identify correct or incorrect information, but rather in what he is likely to do with such information intellectually. If a goal of instruction is to change the students' intellectual style within some academic subject, a test of such achievement must permit him to demonstrate different styles".

Specifically, Heath set out to identify four types of cognitive preferences. These were:-

(a) recall of specific facts or terms (R)

(b) practical application (A)

(c) critical questioning of information (Q)

(d) identification of a fundamental principle (P).

Using a sample of classes following the Physical Science Study Committee (PSSC) curriculum and a sample of those following conventional curricula, he

demonstrated differences between them in terms of cognitive preferences.

He hypothesised that:-

(a) Physical Science Study Committee (PSSC) students should demonstrate a stronger preference for fundamental principle (P) and Questioning (Q) than control group students.

(b) Control group students should prefer memory of facts and terms (M or R) and practical application (A) to a greater degree than PSSC students.

(c) Preference for fundamental principles and questioning should be more positively related to achievement test score for PSSC students than for the control group students.

(d) That preference for facts and terms and for practical application should be more negatively related to achievement test scores for PSSC students than for control group students.

A 20-item device called "The Cognitive Preference Test: High School Physics" was written and administered without pretesting. The instrument bore the form of a

four option multiple choice test, the stem being an item of information or a diagram, while each of the four responses following the stem represented one of Principle, Recall, Application and Questioning. The difference between this test and a conventional multiple choice lay in the fact that all the responses were correct. The students were told this and required to indicate which responses they preferred or found most satisfying to them.

In addition, all pupils in both groups took the School and College Ability Test (SCAT), the cooperative final examination and the concealed figure test.

The sample consisted of 30 PSSC classes of about 1027 pupils and 49 control classes of 2100 pupils.

The means and standard deviations of all tests, for both groups were compared. Results showed significant differences between the mean of the PSSC class means and the mean of the control class means on preference for memory, critical questioning and principles; in the direction confirming his hypothesis but not on application.

In addition, it was found that:-

(i) Cognitive preference for memory of facts and application was negatively related to PSSC achievement while questioning and principles had positive correlation with achievement on

the PSSC test.

(ii) Aptitude had a positive relation to preference for memory of fact in control group ($r = 0.22$) while the relationship was negligible, though slightly negative in the PSSC group ($r = -0.08$).

(iii) The possibility that the differences in cognitive preferences can be accounted for by differences in ability (SCAT) was tested and discounted.

In the discussion of his results, Heath indicated that differences as shown in the result were consistent with the reported objectives of the PSSC course. He also suggested that the generally positive results obtained means that the instrument can identify in a meaningful context, curriculum related differences in cognitive style. The results of his study are particularly encouraging and other studies have been inspired by Heath's work.

Mark (1965, 1967) modelled his "Cognitive Preference Test: High School Chemistry" upon Heath's test, and using the same approach as Heath, compared the cognitive

preferences of students enrolled in the Chemisal Bond Approach (CBA) chemistry classes with the cognitive preferences of students enrolled in traditional high school chemistry classes. The comparison was made in an attempt to identify certain goal differences between the types of curricula. The procedure used in carrying out this investigation followed quite closely that of Heath's in his study of PSSC Physics using R, PA, Q and P model.

These four cognitive preferences were chosen because the "memory" and "practical application" preferences were closely related to the goals of instruction in the traditional course and the "Questioning" and "Principle" preferences were closely related to the goals of the CBA course of study.

With a sample of classes enrolled in CBA chemistry and a sample of classes enrolled in traditionally taught chemistry, the following hypotheses were tested:

(i) Students in the CBA chemistry course and students in the control group show no statistically significant differences in their selection of the four cognitive preferences as measured by the Cognitive Preference Test: High School Chemistry.

(ii) Students in CBA chemistry course and students in the control group show no statistically significant differences in their selection of the four cognitive Preferences when these choices are statistically related to achievement test scores.

(iii) Any statistical differences in cognitive preferences is statistically related to the ability of the students.

An instrument (Cognitive Preference Tests: High School Chemistry) was developed to measure the Cognitive Preferences of the students in the CBA group and the control group. The instrument is a 100 - item test, and the general appearance of an item in the test is that of a four - option multiple choice question. Each item has a stem which presents some information or data of a chemical nature. All the options are correct and students were asked to select the option they preferred most in connection with the introductory information.

Since each of the answers is correct, the Cognitive Preference Test would have an undesirable interdependent quality built into it. That is, if one answer were chosen by a student, three other "correct" answers would be eliminated from the total test score. For example, suppose a student were to have a preference for option (a) for an item while a second student were to have a preference for option (b) for the same item. The result would be that the item would be evaluated one way for the one student while a different evaluation would be obtained for the second student. The resulting ipsative measurement for each student would be distributed about the mean of that student, not about the sample mean. According to Guilford (1954), "individual differences in ipsative measurements have little meaning because there is not a single scale

for all individuals". Therefore the 100 - items were divided into four subtests corresponding to the four cognitive preferences. In this way, it was possible to evaluate, or grade, for the total score of just one of the cognitive preferences. A maximum score for any one of the four subsets was 25.

An item analysis was computed from the Cognitive Preference Test. It was determined that each of the 100 - item was a functional part of the test as a whole. Also, the reliability of the instrument was calculated and it was considered reliable for research purposes.

Mean biserial correlation of test items with total subtest scores for CBA students ranges from 0.33 to 0.48 and for control students from 0.34 to 0.45.

Coefficients of reliability for the subtests for CBA students (N = 433) range from 0.28 to 0.70 and for control (N = 622) range from 0.43 to 0.66.

The estimated reliability of each of the subtest was increased in length to 50 items. The Spearman - Brown Prophecy formula was used for estimating reliabili ties, for CBA (0.44 - 0.82) and for control group (0.60 - 0.80).

A list of all known CBA chemistry teachers were categorized on a two - variable stratification table. The two stratification variables were (a) sex of the teacher and (b) size of community (over or under 100,000 population). A random sample of these teachers was selected and invited to participate in the study.

The teachers that accepted the invitation were categorized on the same two stratification variables used for the CBA group. Results indicated that CBA group was a representative sample from the population.

The non-CBA schools were selected. Invitations were issued to schools in proportion to the CBA population stratification. The distribution of the control sample was tested against the CBA sample by means of the chi - square test. No statistically significant difference was found.

The hypotheses stated were accepted as significant at the 0.05 level and highly significant at the 0.01 level of confidence.

The means and standard deviations of all tests for the pre-test and post-test programs were computed for the CBA group and the control group. The post-test statistics were based upon cluster samples of 24 teachers of CBA chemistry who made up the experimental group (433 students) and 30 teachers of traditional chemistry who made up the control group (602 students) for the post-test data. For example, the mean score for SCAT of CBA group is 40.56. This value is the arithmetic average of 24 CBA cluster means on the SCAT test. Below that statistic the value of 5.29 represents the standard deviation of the 24 CBA cluster means of SCAT.

Data provided indicated that Hypothesis I was rejected for all cognitive preferences except that of practical application. The analyses show that after

having completed a year of chemistry in their respective curricula, the CBA group had a significantly stronger preference for the fundamental principle and critical questioning options in the Cognitive Preference Test items. The pre-test data indicated that there was no difference between the CBA and control group in their preference for the fundamental principle and critical questioning options to the test items.

Although the pre-test data showed no statistically significant difference between the two groups for their preference for the memory of facts option, the post-test data gave considerably different results. A mean of 8.99 was obtained for the control group while a mean of 7.61 was obtained for the CBA group. The two groups had virtually the same mean on the practical application subtest.

Analyses of variance, 2 x 2 factorial design were performed on the data to determine if the ability of the two groups could account for their difference in cognitive preferences. The results indicated that the cognitive preference of these students could not be related to their ability as measured by SCAT. The third hypothesis was rejected.

When achievement test scores were related to the cognitive preferences of students by means of analysis of variance, it was found that neither the ACS cooperative examination nor the CBA final examination were criteria from which to forecast the cognitive preferences of these students. Thus, the hypothesis that the cognitive

preferences as expressed by students could be related to achievement was rejected.

The cognitive style of the students seem tied more to conceptual learning rather than to a verbal structure. Infact it was found that students enrolled in CBA course seem to be able to cope with problem solving situations more readily than their traditional counterparts.

With the differences in structure of the two curricula, the use of standard achievement measures seems an unlikely method of evaluating the CBA course. This is particularly true since many of the achievement tests were designed for the conventional method of instruction. Therefore, the problem of evaluating the CBA course with respect to student learning has to be approached from a different frame of reference - "for students are likely to exhibit same cognitive styles as those implied in the curriculum material used."

Kempa and Dube (1973) carried out a study in Norwich to determine science based cognitive preference orientations in students, subsequent to the study of chemistry at the General Certificate in Education (ordinary level). The instrument used was a cognitive preference test whose subject matter contents corresponded closely to that of current O-level chemistry curricula. As part of the investigation, the effect of academic achievement in chemistry as measured by O-level grades on students cognitive preference profiles was

also examined. The results showed that the cognitive styles of different ability grounds contrasted markedly. High achievers tend to exhibit a high degree of "scientific curiousity" and their acceptance of Scientific Information leaned distinctly towards the "pure science" side. Low achievers lacked scientific curiousity and accept science primarily because of its intrinsic value as a field of intellectual enquiry. Admittedly, these are generalisations which were based on averages not distributions and so had little predictive value. Nevertheless, they provide some guide to the relationship between the cognitive outcomes of O-level chemistry courses and qualities (IQ, achievement) which are strictly speaking non-cognitive.

Kempa and Dube's work suggested that academic achievement is associated with cognitive styles. They demonstrated that high achievers with a particular teacher tend to recall, while low achievers tend to favour application. Therefore there are two variables of importance here: academic achievement and teacher's influence. The question then is, how far can the teacher influence the academic performance of his pupils through teaching? This problem is closely related to one of the problems the present researcher wishes to examine. Can a teacher influence the cognitive style of his pupils through teaching?

Ogunyemi's (1973) study on cognitive styles and students science achievement in Nigeria appeared to buttress Kempa and Dube's claim on the association

between Cognitive Styles and academic achievement. The study investigated the relationship between the two variables using a categorization instrument. Instead of the divergent thinking instrument employed in several of the earlier studies, low and high science achievers (170 science students) were selected by stratified random sampling from grades 7, 12 and the equivalent of the second year of a junior college from a male and female high school in Nigeria and given a cognitive preference test. The results showed a significant relationship between science achievement level and cognitive style for the boys but not for the girls. This result suggests that high science achievers differ significantly in cognitive styles from low science achievers.

Similarly Barnett (1974), explored the relationship between achievement in science, directiveness of teaching style and cognitive preferences. He hypothesised that students who show a strong preference for Q and A could be expected to feel more comfortable and work more effectively using inquiry method than students who show a strong preference for Memory M. He also hypothesised that "a non-directive teaching style could be expected to promote achievement in an inquiry - oriented classroom." Barnett's study thus was concerned with the characteristics of inquiry teaching. These relationships were explored in a study of one semester of instruction in biology. The sample for the study was composed of 1477 tenth grade

biology students drawn from high schools located in the three principal metropolitan areas in Kentucky, Louisville, Lexington and Corington in the United States of America.

One of the three instruments used in the study was the Cognitive Preference Examination - 11 (CPE-11). This instrument was used to classify students on the basis of their Cognitive Preferences. A total of 694 students were classified into three categories by their strong preference for A, M or Q. The second instrument was the Nelson Biology Test which was used to measure achievement in biology. The third instrument was the modified version of "students perception of teachers style" (SPOTS), an examination which requires students to rate the intensity of specific teacher behaviour on a nine point rating scale. This instrument was used to measure teaching directiveness. The data were analysed using Analysis of Variance, Covariance and Correlation Coefficients. Results indicated that students showing preference for Q and A tend to be higher achievers than those whose preference is for M ($P<0.01$). The correlation coefficient also led them to conclude that students who showed strong preference for A learned more effectively than students who displayed strong preference for M.

It is to be noted that in this study, A and Q are characteristics of high achievers as against Kempa and Dubes finding where A is a characteristics of low achievers. In addition, no explicit reason was given

for the omission of principles as a preference.

A study which tried to find out the extent to which the same students show similar or different cognitive preference styles within different disciplines was carried out by Tamir and Kempa (1978).

The study specifically dealt with such questions as:-

(i) How does the cognitive preference of the same student in Physics, Chemistry and Biology compar with each other?

(ii) To what extent do cognitive preferences cut accross these three disciplines?

(iii) What are the effects of sex and school type and locations on the cognitive preferences and their inter-relationships in the three disciplines?

Three cognitive tests one each in Physics, Chemistry and Biology, which had been designed and validated under the supervision of Kempa were translate into Hebrew with some modification and used. Each of these tests comprised 20 items. To ensure that all information incorporated in the tests fell within the cognitive framework of the students, item analysis was carried out. A graded rating procedure was employed.

The sample of 599 subjects was selected through stratified random sampling from different groups representing city academic, agricultural and occupational schools. The alpha chronbach reliability coefficients for the different preference models in different groups range between 0.58 and with a mean of

0.67 for the 20 item test and a mean of 0.81 for the 60 item test.

Results were analysed by a computer using correlations, factor analysis, analysis of variance, correlated t-test statistics. In addition, means and standard deviations were calculated for R, P, Q & A as well as for two other derived measures Q - R (curiousity) and P - A (Utility).

It was found that in all three subjects, Isreali tenth grade students had a strong bias for "P". The general order of preference appeared to be P→ R→ A→ Q. It was also found that some students had similar levels of preference in all subjects as far as Q and R were concerned. However differences appeared with P and A. In the P - A scores for these students, Biology ranked highest and chemistry ranked lowest. It was established that cognitive preferences cut across the three disciplines. To some extent cognitive preference appeared to depend on the subject matter area.

A one-way analysis of variance revealed only two statistically significant sex differences at the 0.05 level. Boys had a higher "R" scores in Physics while girls had a higher "P" scores in Chemistry. In all other comparisons, there were no significant differences.

On the type of school, it was found that students in occupational schools have the highest preference level for "R", students in city schools have the

highest preference level for "P" and "Q" while students in agricultural schools have the highest preference level for "A" in the Physical Sciences. Students in agricultural schools were also found to be more similar to each other than to students in city academic schools.

On Cognitive Preference and achievement, low positive correlations were found between the final year school grade and cognitive preference score in "P" as well as in P - A.

In their discussion, Tamir and Kempa noted that even though a general style in science which cuts across the discipline does exist, it does not account for all of the variances. In addition, there are specific cognitive styles which exists for each of the three disciplines and which differ from each other. They suggested that these studies may be able to find what portions of the variance are accounted for by the different disciplines compared with science as an entity.

Ogunsola (1981) investigated the cognitive styles of students of Chemistry in the School of Basic Studies (SBS) of Ahmadu Bello University, Zaria, Nigeria. The study was designed to investigate the most prevalent cognitive styles among chemistry students in the SBS, using Heath's (1964) model;to measure differences in cognitive styles between male and female students and to measure differences in cognitive styles between students who schooled in educationally disadvantaged areas and those from other areas of Nigeria.

The subjects were 156 fresh SBS students who were among early arrivals and who registered for chemistry in August 1981. The subjects were of both sexes with an average age of 17 years.

A 40 item test based on the SBS entrance examinations over the years 1978-1981 and structured to conform to the format suggested by Heath (1964) and Kempa and Dube (1973) was developed. The test construct was validated using the framework provided by Van den Berg et al. (1978). The instrument was administered in August 1981 during the second week of the SBS students' orientation.

The frequency of selection of options in the various categories was used as the unit of scoring, data analysis and interpretation. Contingency tables for frequency distribution of respondents on the four cognitive styles, sex and location of schools attended were set up. The nonparametric chi squared statistic was considered appropriate for the analysis because the data were only frequency counts.

The data suggested that R and P options are selected four times as often as the combined A and Q options. This may mean that the Nigerian subjects have a preferential cognitive style for recall (R) followed by Principle (P), unlike their Israeli subjects in Tamir's (1981) study who had greater average score in Q. The chi squared value obtained for each of the four cognitive styles by sex group was not statistically significant at the criterion

level of 0.05. This result is in agreement with Tamir and Kempa's (1977) findings. Again the value was not statistically significant at the criterion level of 0.05, in the case of cognitive style according to location of previous schools. It appears that there is no relationship between school background and preference for cognitive style in Nigeria.

It was concluded that most Nigerian Secondary School graduates were inclined to recall and least inclined to critical questioning (Shuaibu and Ogunsola, 1983). The general order of preference seemed to be R→ P→ A→ Q and the distribution was in the ratio of 5:3:1:1.

McNaught (1962) reported a study of the relationship between cognitive preferences and patterns of achievement in chemistry for grade 12 students in Australia.

It was hypothesized that:-

(i) Students who develop cognitive preferences consistent with those implied or stressed by the Higher School Certificate chemistry course tend to perform better on an end of course achievement examination than do students whose cognitive preferences are not consistent with these implied preferences.

(ii) Higher cognitive preference for a particular preference is positively correlated with performance on the sorts of cognitive tasks implied in that preference. The sample consisted of 304 High School Certificate (HSC) students in Victoria. These students had studied

Integrated Science in grades 7 - 10 and Chemistry in grades 11 and 12. A Chemistry cognitive preference test was administered shortly before the students sat for their HSC examinations. Both cognitive preference data and achievement data were obtained for 288 students.

The cognitive preference data were analysed using both a modified R-technique factor analysis and the multidimensional unfolding technique. From the analyses, it appeared that a students cognitive preference could be characterised in terms of two scores:-

(i) Scores on scales QM and PA or

(ii) Scores on scales QA and PM.

For an example, a score on scale QM is equal to the score on cognitive preference for Q minus the scores on cognitive preference for memory.

Thus a score on QM scale = score on C, P, "Q" minus a score on C, P, 'M'. A high score on scale QM indicates a greater preference for Q than for memory, while a low score indicates greater preference for "M" than Q. Scores on scales PA, QA and PM were calculated in a similar way.

The scores obtained for the 1974 HSC chemistry examination were used as the achievement data. These were categorised into:

(i) Extended Answer (EA) and other (O) i.e. multiple choice item and numerical problems.

(ii) different cognitive complexity, i.e. knowledge (K) and higher than knowledge (HK) as defined by Bloom et al. (1956).

Correlation coefficients were computed between the scores on each of the CP scales QM, PA and QA, PM and total scores on the HSC chemistry examination for 288 students. The correlations were significant at the 0.05 level of significance for the cognitive preference Scale PM and QM. Correlation results, seemed to show that cognitive preference is related to chemistry achievement.

To further investigate this, students were assigned to high and low groups for each cognitive preference. This depended on whether a student's score was greater than or less than the mean score for that scale. Analysis of covariance was used to investigate whether level (high or low) on a cognitive preference scale was related to differential performances on different types of tasks. Results obtained led to the conclusions that:

(i) Students who score high on PA scale tend to perform relatively better on higher than knowledge tasks than do students who score low on scale PA and vice versa.

(ii) There is no difference in relative performance on higher than knowledge and knowledge tasks between students scoring high and low on the other cognitive preference scores.

(iii) There is no difference in relative performance on extended answer and other tasks between students scoring high and low on any of the cognitive preference scales.

The result of this study implied that it would be advantageous if teachers could develop in their students

cognitive preferences such that P and Q are preferred to A and M. It was recommended that the issue of how a learner's cognitive preference can be changed should be a fruitful avenue for further research. And this is one of the considerations under the present study.

Okebukola (1984/5) carried out a study on cognitive style among Yoruba students in Ondo State, Nigeria. The study was to:-

(i) determine the cognitive preference orientations of students using the traditional and CESAC Biology syllabus and

(ii) relate students cognitive preferences to achievement in the two biology syllabuses.

The sample consisted of 128 class four biology students (72 boys and 56 girls with a mean age of 15.2) enrolled in a secondary school offering traditional biology syllabus option and 119 class four biology students (68 boys, 51 girls with a mean age of 14.91) enrolled in a Secondary School offering the CESAC biology syllabus option in the same state.

A 40 - item biology cognitive preference inventory BCPI (second edition) developed and validated by Tamir (1981) and Biology Achievement Test - BAT - a 40 item multiple choice test with five alternatives (one correct answer and four distractors) were used for collecting data.

The scores for the four cognitive preference areas were obtained using McNaught's (1982) procedure:-

Score on each cognitive preference = Total No. of item + No. of Items on which option for that cognitive preference were chosen as most appealing minus No. of items on which options for that cognitive preference were chosen as least appealing.

BCPT was administered the week following the administration of BAT. Both instruments were administered at about the same time in the two schools selected for the study.

Results showed that most of the subjects using the traditional biology syllabus were reaall oriented while most of those on the CESAC syllabus were application oriented. Since both R and A had earlier been found to be characteristics of lower achievers, one may not be surprised why Kanu (1983) found no difference in the achievement of CESAC and non CESAC students. In addition, students with principles and recall cognitive preferences performed significantly better on the traditional biology syllabus when compared with students with A - Q, the reverse being the case for the CESAC group.

In the discussion and conclusion, Okebukola inferred that Cognitive Preference of students exert considerable influence on their performance in biology. The result also strengthened the validity of the cognitive preference

construct and indicates that a mismatch between cognitive preference orientations of students and curriculum material may be responsible in the declining performance of students in biology.

In many British journals, students cognitive styles tend to be classified as holists and serialists (Pask and Scott, 1972, Pask, 1976a, b; Ford, 1985), in contrast to Heath's model.

For instance, Pask (1976b) worked on the styles and strategies of learning. The researcher suggested that matching and mismatching teaching strategies with learner's preferred learning strategies may have considerable effects on learning. In an earlier paper, Pask (1976a) introduced conversational techniques, some involving a human participant in dialogue with a student, others involving a mechanically or computer implemented "participant" through which the student "talks to himself" under restrictions imposed by the device.

Pask (1976b) argued that the learning of complex material involves two distinguishable elements - building a description of what may be known (a conceptual map, essentially an overview, of how various topics interrelate), and building procedures (essentially examining the more detailed evidence and procedures supporting the overview). The first element, description-building, is most effectively achieved by means of a global study approach; the second element, procedure - building, is most effectively achieved via a local study approach.

Pictures of extreme forms of global and local approaches were obtained in a series of experiments (Pask and Scott, 1972; Pask 1973, 1976a, b; Robertson, 1976). In these experiments, two learning strategies were identified. Holists use a global approach concentrating first on building broad descriptions into which the details may be fitted. Serialists use a local approach, concentrating more narrowly on procedures, before the overall picture emerges.

In freer, more normal learning Pask argued, individuals may be usefully classified as comprehension learners - who tend to behave like holists; operation learners - who tend to behave like serialists; and versatile learners who tend to galvanate between the other two.

These differences seemed to be of degree. Comprehension learners have a bias towards description - building; operation learners a bias towards procedure - building. Extreme comprehension learners may have a lack of procedure - building capability pronounced enough to impair their learning. They are well able to build a generalized overview of a subject (more like principle), but are unable to pay attention to more detailed supporting evidence (Questioning). In this way, they often display a globetrotting - making invalid links between topics or being too ready to generalize without sufficient evidence. Extreme operation learners may lack sufficient description - building

capability, the result which is well described as 'not seeing the wood for trees' and it is termed improvidence by Pask. Versatile learners are able to engage in both global and local approaches, succeeding in achieving full understanding comprising both descriptions and procedure. Generally in order to achieve full understanding, it requires the use of both learning approaches - a holist-like global building up of a relatively superficial overview on the one hand and a serialist - like construction of local facts and details which fit into the broad overall framework.

Pask also argued that versatile learners are likely to adopt either holist or serialist strategies "by instruction or on whim", and to change strategy, if the subject matter is changed (Pask 1976c).

However, when a sample of 62 polytechnic students was classified as adopting a holist or serialist approach to a preliminary free learning task, the effects on learning of subsequent matching and dismatching of learning materials were statistically significant for each individual in the sample (Pask, 1976c). It may be that Pask's sample contained no learners who were versatile in the sense of being able to adopt either holist or serialist strategies with success. However, it may equally be that some learners are 'versatile' in the sense of being able to avoid learning pathologies by combining global description - building with local procedure-building,

but nevertheless need to do so using one or other sequence:- a holist - like global description involving building predominantly before local procedure-building, or a serialist - like local procedure - involving building predominantly before global description - building. Either sequence may achieve the end product of both descriptions and procedures built via the use of both global and local approaches.

Ford's (1985) study allowed for the second possibility by the use of a questionnaire designed to assess preferences for either holist - or serialist - like sequences in learners who may be versatile in the sense of being able to combine global description - building with local procedure - building as well as learners with a discernible comprehension learning or operation - learning bias.

Generally holist - learners have scores higher from serialist presentations than have serialists from holist presentations. Pask (1973) noted that, consistent with "versatility" in the second sense, perhaps the typical versatile learner has a holist bias. It is also worth noting that Enwistle's factor analysis, linked comprehension learning with a 'deep' meaning - oriented approach to study; operation learning with a ' surface', reproductive approach resulting in less successful academic achievement (Entwistle, Hanley and Haensell, 1979, Entwistle, 1981).

Pask (1976b)concluded by stating that it is

possible with a few exceptions, to teach students to learn more effectively by the application of sophisticated principles of learning. The principles can, however, be presented in a simple, non technical manner suitable for use in a classroom.

Ford (1985) tried to explore the extent to which a group of experienced and successful learners, such as postgraduate students, might be expected to be versatile learners, in the sense of being able to learn equally well from holist and serialist learning materials. The study also examined the extent to which holist and serialist competence may be predicted by relatively "quick and easy" questionnaire instruments-basing its foundation on Pask (1976a, b) research work. Pask suggested that matching and mismatching teaching strategies with learner's preferred learning strategies may have considerable effects on learning.

An important question raised by Pask's work is "to what extent will experienced and successful learners - for example post-graduate students - likely to be, through selection or development, versatile learners, able to adopt either holist or serialist strategies?" Clearly if the majority of such students were equally able to learn from information presentation designed to suit either holist or serialist strategies, then the implications of Pask's work on learning styles for everyday teaching and learning at this level would be less pronounced than if this were not the case.

The study shed some light on this question by exploring:-

a) The incidence in a sample of postgraduate students of competence to learn equally effectively from materials designed to suit (i) holist and (ii) serialist learning strategies as measured by two learning tests.

(b) The extent to which such competence may be predicted by relatively 'quick and easy' instruments in the form of (i) Entwistle's Short Inventory of Approaches to Studying', and (ii) a specially designed study Preference Questionnaire".

Eighty-three postgraduate students, 22 MA, 16 M.Sc. and 45 PGDE students completed the "Short Inventory of Approaches to Studying" and a specially designed 'Study Preference Questionnaire". Twenty-six of these students - 16 MA, 8 BSc. and 3 PGDE - also took two tests designed to measure their competence in learning from materials designed to suit a redundant holist and a serialist learning strategy.

For the learning test results, two students scored equal points on both learning tests. The other 24 individuals were classified as holists or serialists according to the test on which they achieved higher points.

Scores for each individual on the items designed to assess comprehension and operation learning on the 'Short Inventory of Approaches to Studying', and the items designed to assess holist and serialist

preferences on the 'Study Preference Questionnaire" were compared with the individual's assignment as holist or serialist from the test scores.

For the 'Study Preference Questionnaire', despite the small number of subjects, the correlation was statistically significant using the Sign Test and treating all scores as ordinal. The best individual predictor was question 16, with a correlation significant at $P < 0.01$.

Mean scores for 'Matched' (i.e. students classified as holists, using the 'Study Preference Questionnaire' for learning from holist teaching materials and serialists for learning from serialist materials) and 'mismatched' conditions were 18.35 (SD = 6.85) and 14.4 (SD = 5.7) respectively.

The Short Inventory of Approaches to studying to predict holist and serialist competence was less effective. A comprehension learning bias correlated with holist competence and an operation learning bias with serialist competence in 15 out of 25 cases. Correlation between these biases and test score differences were not significant, using the Wilcoxon test.

The central issue addressed by the study was: to what extent might a group of experienced and successful learners like postgraduate students be versatile, in the sense of being able to learn equally well from teaching materials designed to suit holist and serialist learning strategies?

However, the concept of being able to learn equally well from such different materials can be interpreted in at least two ways:

(a) able to achieve a similar level of performance after learning from holist and serialist materials (regardless of whether such a level is high or low compared to any particular norm),

(b) able to achieve a reasonably high level of performance after learning from holist and serialist material.

A 'similar level' of performance may be calculated by analysing for each individual the difference in scores between the two tests, as a percentage of each individual's 'potential', defined here as his or her maximum scores on either test. Such a measure relates only to each individual's relative performance on each test, and not to the performance of the group as a whole.

A 'reasonably high level' on the other hand, relates the individual's performance to some common standard measured at group level.

The above results do lend some support to the following suggestions.

a) One cannot necessarily assume that experienced and successful learners like PG students will tend to be versatile in the sense of being able to learn equally well from materials designed to suit holist and serialist learning strategies.

b) It is possible to some extent to identify students likely to learn more effectively from either holist or serialist materials by using a relatively 'quick' and easy' questionnaire 'instrument'.

The implications of matching and mismatching teaching and learning strategies for 'normal' teaching and learning must be further explored. The study reported here dealt only with factual recall from the equivalent of less than one normal lesson's worth of information. Just what scoring say, four points less on one such test when mismatched means in terms of normal study performance is not clear.

Pask and Scott (1972) noted that "since human beings are highly adaptable it may be possible for an individual with any sort of competence to learn in the end, according to any teaching strategy. But the experiments show, very clearly indeed, that the rate, quality and durability of learning is critically dependent upon whether or not the teaching strategy is of a sort that suits the individual".

2.3: Cognitive Styles Implied in Curriculum Materials.

Of recent, efforts have been made by groups of science educators to provide r new and relevant curricula with better instructional approaches. An important characteristic of the new science curricula has been an increased emphasis on concept formation, scientific principles, inquiry process, critical thinking and so on (Tamir and Kempa, 1978). Each curriculum material therefore shows distinctive characteristic orientation, which

reflects the designers cognitive preference.

In an effort to help meet the widely recognised need for new tests necessary for assessing new curricula, Atwood (1968) developed a Cognitive Preference Examination - Chemistry (CPEC). The test is composed of forty-one items covering information from the first ten chapters of CHEM study text.

Atwood compared the performance on the CHEM semester achievement test among groups of students classified on the basis of frequency of choices on the CPEC. The main purpose of the study was to support or refute the expectations that students showing a strong preference for M should be at a disadvantage in CHEM study when compared with students showing a strong preference for P, Q and A. And that students showing a relatively strong mixed preference for M and anyone of the three others should be expected to also have difficulty in CHEM study course. The sample consisted of 775 subjects.

An analysis of variance was used to test the hypothesis. Means and standard deviations for the groups were also calculated. Results indicated that subjects showing a strong preference for memory in combination with a second cognitive preference tend to be at a disadvantage relative to CHEM achievement when compared to subjects expressing other pairs of cognitive preference. In addition, a strong preference for A is more advantageous relative to CHEM achievement than a strong preference for Q and P. In the study, Atwood, appeared not to be concerned with the identification of cognitive styles of the pupils.

Mackay (1972) used a cognitive preference test similar to that of Heath on the PSSC students in schools in Victoria, Australia. He surveyed PSSC literature and concluded that the course placed increased emphasis on P and decreased emphasis on M, when compared with traditional courses. In addition, the course concentrated on the theoretical aspect while little emphasis was given to the technological application of Physics.

From these findings, he derived two objectives for the course:

(1) Students should develop a greater preference for Q and theoretical extension of information over practical application of physical information.

(2) Students should develop a greater cognitive preference for identification of principles over rote remembering of specific facts of terms.

He thus used two cognitive preference scores (Q - A: and P - M) for his test. He was able to demonstrate changes in the cognitive preferences of pupils over two years in the direction specified by the objectives.

However, he did not make clear the significant levels of his analysis. He also appeared to accept the appropriateness of "cognitive preference" as a measure of 'cognitive style', but gives no theoretical interpretation of either.

Tamir (1975 and 1977) examined the effects of school environment, the attitude of teachers towards an enquiry oriented approach (i.e. curricular bias), the nature of the curriculum and that of the subject matter on the cognitive preference styles of students.

An analysis of subject matter content of three current biology syllabuses in Israel was made. The analysis was made so as to ensure that all information incorporated in the test fell within the cognitive framework of the subjects. This content analysis in addition, was a necessary condition for the validation of the instrument. The test was a 40-item test.

The subjects were 989 stratified random sample of Israel 12th grade students. Of this sample, 408 studied Israel BSCS while 581 studied traditional biology. Their teachers numbered 46. The BCPT was administered and the graded ratings procedure suggested by Kempa and Dube (1973) was employed. Data were analysed by a computer using means, standard deviations, distributions, correlations, factor analysis, analysis of variance, analysis of covariance and t-tests statistics.

Results showed that both the teachers and their classes have a very high preference for principles ($\bar{X}$ = 112.48) and they do not differ in their preference either for principles (P) or for principles - application (P - A).

It was also observed that while the teachers revealed a very high preference for Q ($\bar{X}$ = 155.22) and a very low preference for R ($\bar{X}$ = 82.54), their students exhibited on the average, practically identical levels of preference for R ($\bar{X}$ = 96.17), Q ($\bar{X}$ = 96.26) and A ($\bar{X}$ = 94.67). Data obtained also showed that the two samples share the negative correlation between Q and R on one hand. And on the other hand, while R and A of the teachers are negatively correlated and constituted a distinct factor, no such clear cut relationship was found for the students. Hence the third hypothesis was only partially supported.

Results also showed that cognitive Preference styles of similar students in Chemistry and Biology were quite different. In Chemistry, all students tend to prefer R & P much more than in biology, and the reverse appeared to be true regarding Q and A. However, it was difficult to determine whether this was a result of the nature of the curriculum or the nature of the discipline.

Or recent, efforts have been made by groups of science educators to provide a new and relevant curricula with better instructional approaches. An important characteristic of the new science curricula has been an increased emphasis on concept formation, scientific principles, inquiry processes, critical thinking and so on (Tamir and Kempa, 1973). One of such recent curricula, is the Nigerian Secondary Schools

Science Project (NSSSP).

The NSSSP is a group effort of a number of Nigerian science educators. The Project is an outcome of an intensive workshop sponsored by the Comparative Education Study and Adaptation Centre (CESAC), University of Lagos and is based on the syllabus developed by the Science Teachers Association of Nigeria (STAN). There are students text consisting of three separate volumes of books, 1, 2, and 3 corresponding to forms 3, 4, and 5 respectively and in each of the three science subjects of Physics, Chemistry and Biology. Each subject area also has a teachers' guide.

At the 1969 Nigerian Science Curriculum Conference, strategies for producing new instructional materials aimed at correcting the defects in the existing books were evolved. The ensuing cooperation between CESAC, Science Teachers Association of Nigeria (STAN), and some Nigerian Scientists resulted in the production of the Nigerian Secondary School Science Project (NSSSP) texts in biology, chemistry and physics between 1970 and 1972. There is a WASC examination syllabus designed for evaluating students achievement on the project, often referred to as the WASC alternative syllabus.

CESAC's approach emphasizes discovery learning, explanation and application. Rote learning of facts was discouraged completely. For this reason, students were taken through series of activities to strenghthen their experiences. They were given enough facts about a subject

forgets thereafter. This approach and the attitude it generates, is highly superficial and may not inculcate the habits of mind that could create science and use it effectively in solving the country's development problems. CESAC takes the view that science essentially consists of definitions, observations, experimentation and analyses. Hence, none can appreciate the value of science if not actively engaged in these fundamental processes in the course of learning science. Therefore CESAC's approach encourages more active participation. Students are encouraged (or even compelled by the structure of the teaching process) to learn by enquiring and self-discovery guided procedure".

Omoifo (1986) carried out a study in Nigeria to find out the relationship between the cognitive style of CESAC and the cognitive styles of students who used the materials. She used Heath's model to analyse the contents of the Comparative Education Study and Adaptation Centre (CESAC) science curriculum materials (in biology and chemistry). The purpose was to find the extent to which claims for the programme designers, in respect of helping students develop particular modes of learning are consistent with the nature and contents of the curriculum materials.

The cognitive styles of students who used these materials were also examined in relation to the cognitive styles implicit in the nature of the curriculum materials.

The subject of the study include 308 Chemistry - Biology students from the School of Basic Studies (SBS) Ahmadu Bello University (ABU), Zaria.

The following null hypotheses were tested:-

i) CESAC (Chemistry and Biology) students will demonstrate the same cognitive style as non-CESAC students.

ii) The styles of CESAC students will not be related to the styles implicit in CESAC materials.

iii) CESAC students will demonstrate the same pattern of cognitive styles in biology and chemistry cognitive preference tests.

The students were fresh from secondary schools and were enrolled for pre-degree programmes during the 1985/86 session. This selection was intended to control for influences of other science textbooks which they may be using during their course in the S.B.S.

Her instrument like others, provided four current possible choices for each of the 40 items, with each corresponding to a different type of cognitive style.

The test was grouped into two sub-tests:-

(i) a 20-item chemistry sub-test adapted from Ogunsola (1981) cognitive preference text (OCPT), the Cognitive Preference Text (CPT) and the Combined Cognitive Preference Texts (CCPT), revised from by Tamir (1978).

(ii) a 20-item Biology sub-test adapted from Biology Cognitive Preference Inventory (BCPT) - second edition developed and validated by Tamir (1980).

The test was administered to the students on the fifth day of the orientation programme. This was to enable most students to register and get settled for work.

In task analysing of the CESAC textbooks, the sub-sections of chapter were read, key statements emphasising each of the preference modes were identified. For example, the learning of formulae and symbols were regarded as emphasis on recall. A question which critically examines and extends a given information was accepted as questioning. The use of scientific fact in industry or everyday life was regarded as application. The mode that was greatly emphasised was scored four (4), the next three (3), then two (2) and the least emphasised was score one (1).

The rating for each chapter of a book was tabulated. In order to minimise possible bias and increase

the reliability of data collected, the analysis was done repeatedly until there was little difference between the last two analyses. The supervisor also had a check on the analysis.

Omoifo found that the cognitive styles implicit in the contents of the CESAC chemistry textbooks (Books I, II and III) were more of recall than principles, application and questioning. On an average, the distribution of implied cognitive styles in the contents of the chemistry texts (books, I, II and III) was of the order R > P > A=Q and in the ratio 43: 2:2 approximately.

In a subsequent analysis of the cognitive preference of students who had used CESAC chemistry materials, it was found that the majority of the students were recallers. The mean ratings for the 26 students who indicated that they had used CESAC chemistry books were found to be 2.8, 2.6, 1.9, 1.8 for R, P, A and Q respectively. From a previous study, it was found that SBS/ABU Chemistry students (most of who may not have used CESAC materials) showed a cognitive style of the order R (5)→ P (3)→ A (1)→Q (1) Shaibu and Ogunsola, 1983). Omoifo (1986) also found that non-CESAC chemistry students had a cognitive style orientation of the order R = P > A > Q.

The ratio being 2.5: 2.4: 1.9: 1.8 respectively. These results suggest that curriculum materials may have little or no effect on students cognitive styles.

2.4: Cognitive Style: the teachers influence on the Students

Teachers do seem to have some measure of influence on their students cognitive style. If the cognitive styles of the teachers and students are known, it may be possible to match teachers with a particular style to students of that same style. Such a match does have some potential effects on learners achievement.

Heil, Powel and Feifer (1960) suggested that the teachers' influence was conditioned by both the type of teacher and the type of child with whom he deals. These researchers suggested that the identification and examination of teacher types and student types may be crucial for understanding teacher effectiveness. Thalen (1968) believed that the nature of classroom teaching and learning was dependent on the particular combination of students and teachers. He argued that a teacher's class should be composed of students like those who have been most successful with him in the past, those who Thalen described as the "teachable". It is in line with this that the construct of cognitive style has been explored by several researchers.

Tamir's (1975 and 1977) works provided an insight of the influence of the teacher on the cognitive style of his students, since significant differences were found among students in different types of schools who studied different curricula and among teachers with different approaches to enquiry teaching. The differences he found

with the teachers corresponded to those in the students preference patterns, which may be interpreted as some support for the effect of the teacher on their students. The details of one of his studies are described below.

Tamir (1977) carried out a study to find out the relationship between the cognitive preferences of students and their teachers in Biology. This study was an outgrowth of two previous studies in which significant and substantial differences were found in cognitive preference patterns among different groups of high school students who had studied biology for four years. Biology teachers (N = 46) of the students (N = 989) participated in the two studies and both groups were asked to respond to the same Biology Cognitive Preference Test (BCPT). Thirty-seven teachers responded. BCPT is a 40-item instrument to which the subjects responded by assigning a rank of 4 to the most appealing and a rank of 1 to the least appealing statement. The mean responses of the teachers were compared with those of their classes by t-test.

The following hypotheses were tested:-

1. Significant differences will be found between the teachers and their students in their cognitive preference scores.
2. The cognitive preference of the teachers will not correspond to those of their students.
3. Inspite of the hypothesized differences in the levels of cognitive preference scores between the teachers and their students, similar interrelationships among the four cognitive preference areas will exist for both groups.

Tamir reported "reasonably" high reliability values of 0.71 for teachers and 0.73 for students in application, ranking somewhat lower than the other three areas. Ranges in both cases are students: 0.73 - 0.84 and teachers: 0.71 - 0.91.

The critical test of the second hypothesis was done in the following manner:- the mean scores of the classes for each of the cognitive preference areas were correlated with individual scores of the teachers in those areas. When significant correlations were found, the hypothesis of no identification had to be rejected. Results showed that both the teachers and their classes had a very high preference for principles ($\bar{X}$ = 112.48 using rating scale), and they do not differ in their preference either for principles or for Principles - Application (P - A). The high preference for principle which was found to be a general characteristic of Israeli science students appeared to be also characteristics of their teachers. It was also observed that while the teachers reveal a very high preference for Q ($\bar{X}$ = 115.22) and a very low preference for R ($\bar{X}$ = 82.54), their students exhibited on the average, practically identical levels of preference for R ($\bar{X}$ = 96.17) Q ($\bar{X}$ = 96.26) and A (94.67). On the basis of the data available the second hypothesis could not be rejected. Zero correlations were reported between the preferences of the classes and their teachers. An attempt was made to find

whether classes and students in a more homogenous setting may behave in a different manner. The null hypothesis was still not supported.

The third hypothesis was tested by comparing

a) the correlations between the four cognitive preference areas of the teachers with those of their students,
b) the result of two separate factor analyses with varimax rotation.

In addition the effect of the school environment, sex, curriculum, and attitude towards enquiry teaching on the cognitive preferences of the teachers were compared by analyses of variance.

The results showed that out of 36 possible correlations, none were found in agricultural schools, three in city, and eight in Kibbutz schools. Of these, only in the Kibbutz schools did some congruence exist between teachers and classes. This congruence appears in the area of P and P.A. On the basis of these results, it may be concluded that the responses of the students, by and large did not represent a conforming behaviour to please their teachers, but rather their own personal preferences.

Since significant differences were found among students in different types of schools who studied different curricula, from teachers with different approaches to enquiry teaching, separate comparison based on these independent variables were conducted for the teachers. In none of the comparisons were there statistically significant differences at the 0.05 level. Yet some trends were detected. Teachers in agricultural schools had the highest preference for A ($\bar{X}$ = 105) and

lowest for Q ($\bar{X}$ = 102) while the Kibbutz teachers had the lowest preferences for A ($\bar{X}$ = 92) whereas their preference for Q was identical with that of the city teachers ($\bar{X}$ = 119). These differences corresponded to those found in the students preference patterns. They may be interpreted as some support for the effect of the teacher on their students but an equally plausible interpretation is the existence of an effect of the school environment on cognitive preferences. Neither significant difference nor even trends, could be found on the effects of the sex of the teachers, the curriculum they taught (BSCS vs non-BSCS) or their favouring of enquiry teaching on their cognitive preferences.

The final data obtained presented the interrelationships among the four cognitive preference areas for the teachers and the students. It showed that the two samples share the negative correlation between Q and R. On the other hand, while P and A of the teachers were negatively correlated and constituted a distinct factor, no such clear-cut relationship was found for the students. Hence, the third hypothesis was only partially supported by the data.

Schmedemann and La Shier (1967/68) investigated the relationship between students cognitive preferences and certain teacher characteristics such as teacher's cognitive preference, teacher warmth, teacher demand and teacher use of motivation.

The null hypotheses of the study were the following: (1) there is no relationship between cognitive preferences of teachers and the cognitive preferences of the students, (2) there is no relationship between teacher warmth and the cognitive preferences of the students, (3) there is no relationship between teacher demand and the cognitive preferences of the students, and (4) there is no relationship between teacher use of motivation and the cognitive preferences of the students.

A total of 250 PSSC teachers were asked to participate in the study. The number of teachers who agreed to take part in the study and indicated that they used the PSSC test was 31. The tests and inventories were administered by the participating teachers in February, 1966. The classes of these 31 teachers were placed into either Group O or Group N according to whether the students had taken the old or new form of PSSC Test Five. This procedure was used since there was no evidence that the two forms of the test were equivalent. The purpose of dividing the sample into two groups was to make possible the re-examination of any significant correlations with the aptitude variable partialled out. In addition the use of two groups provided for a concurrent replication of the study. Since most of the data which was collected were assumed to be ordinal in nature, nonparametric statistical techniques were selected as being most applicable to the data.

The Kendall rank correlation coefficient was used for the analysis and the authors concluded that there was no appreciable interaction between the student's median cognitive preference score and the teachers cognitive preference or the students' evaluation of the teacher on the warmth 'demand' and use of 'motivation' scales.

Heath (1964) held that ".....the classes of different (PSSC) teachers manifest varying performance on the Cognitive Preference Test. This suggests that teacher - effects, as well as curriculum effects, can be identified by Cognitive Preference testing".

In their study, Schmeddemann and Lashier did not give reasons for choosing to administer the test to PSSC students other than the fact that, the test had already been used by Heath. They made no attempt to discuss what was being measured. There were weighted measures arbitarily selected after inspection of PSSC goals (WM = WA = I; WP = 2, WQ = 3).

2.5: Methodological Issues and the Treatment of Cognitive Styles Data.

To get at what goes on in the classroom, interactionists use classroom observation techniques. The approach had been used to describe typical classroom behaviour as a model for teacher preparation. There are two approaches to classroom observational studies:- the direct and the indirect approaches. Under this section, a review is made of the indirect approach to classroom observation.

Result indicated that there were no statistical significant difference between ipsative and normative subtests in 'P', 'Q' and 'P - A'. The differences between R, A and Q - R were relatively small. A higher 'Q' and lower 'R' cognitive preference pattern of students following inquiry - oriented curricula was found, confirming the results of earlier studies (Heath, 1964; Kempa and Dube, 1973). This performance pattern represents a very high level of intellectual curiousity and desire to learn more.

It was also found that students who had 'A' grade in their high school biology had higher preference for principles, 'P' than do the 'B' students. Non-science majors had the lowest preferences for recall while premedical students had higher preferences for 'P' and 'Q'. Students in higher grades i.e. who have spent more time in the school had on the average lower preference scores for R and higher preference scores for 'P'.

No statistically significant differences were observed in cognitive preferences among groups of the sample divided according to gender, religion and hobby. Students in the sample were much curious about information of a biological nature than about that dealing with microbiology. They also preferred applied aspects of botany to application of other topics such as evolution. Similar effects of subject matter specifically were reported by previous studies (Tamir, 1975), but the magnitude of this effect was not estimated.

The reliance on "objective" sources of information about students, as in the use of observers and recorders to judge students behaviour, has been criticised recently.

A major use of classroom observation studies has been to describe typical types of behaviour as models for both teacher preparation and behaviour modification.

Martins (1984) identified the prevalent behaviour among the Nigerian Secondary School students in their science classes. The approach to identifying students behaviour was indirect, as opposed to the better known direct classroom observation techniques. In the study, instead of relying on data gathered and analysed by external observers, science education student teachers who had had more than one year teaching experience, were requested to imagine and describe the intellectual transactions of five typical students in their science classes.

The student - teachers description of their students behaviours were classified into eight-paired categories of students behaviours: Attitude to rules and regulations (1) Personality (2) Intelligence (3) Attitude to Peer group and teachers (4) Attitude towards science (5) Attitude im science work (6) creativity (7) and self-concept (8). The students behavioural descriptions appeared as polar adjectives.

Since these adjectives contrasted with those that are to be found in classical direct classroom observation studies, it was felt inadvisable to disregard the role and judgement of the teachers in the assessment of their students.

Martins approach to "indirect observation" has been employed in the present study to identify the students cognitive styles (using the teachers).

2.6: REST DEFINING ISSUE TEST (DIT)

The CPT format of Heath (1964) has been found to be problematic when it comes to scoring and the stem is suggestive of the keyed cognitive style. To get round the problems, the Rest (1974) Defining Issue Test (DIT) offers itself as another means of reverifying the cognitive style construct and their distribution among the subjects for the present study. The DIT approach has been reviewed under this section.

The teaching of attitude which is somewhat comparable to Cognitive Style is notoriously difficult. Rest (1974), like Heath, has pioneered a means that has the potential to cause measurable changes in moral judgement. He constructed the Defining Issues Test (DIT) to assess crucial moral issues in situations involving moral dilemmas. The DIT is a widely used instrument which has been employed in assessing over 100 different samples in four countries (Rest, 1977).

The DIT consists of six hypothetical stories and subjects were required to evaluate a set of 12 issue - statements. The subjects rated how important each issue statement was in deciding what ought to be done. This was a recognition task which enabled the subjects to reason. In addition, the subjects were required to rank four most important choices, making objective scoring possible. Each of the 12 issue - statements associated with a story was written to examplify some characteristics of one of the stages of moral development.

For the details of the DIT and how it is used, the reader is referred to Okatahi (1984). Okatahi (1984) modelled her test upon the Rest (1974) Defining Issue Test and using the same approach for Nigerian subjects. Okatahi's study was an attempt to increase the moral judgement level, locus of control and self-concept of individuals.

The subjects consisted of 112 undergraduate students of Ahmadu Bello University, Zaria, Nigeria. They were randomly assigned to experimental and control groups of 55 and 57 students respectively. The experimental group was randomly re-grouped into four discussion sessions.

The following hypotheses were tested:

(1) Moral dilemma discussions should directly enhance subjects' principled reasoning.

(2) Moral dilemma discussions should enhance the subjects' locus of control.

(3) Moral dilemma discussions should enhance the subjects self - concepts.

(4) There is a relationship between subjects, scores on moral judgement as measured by the Defining Issues Test and their scores on locus of control as measured by the Internal, powerful others and chance scales.

(5) There is a relationship between moral judgement as measured by the Defining Issues Test and self concept as measured by the Revised Personal Attribute Inventory.

(6) There is a relationship between locus of control as measured by the Internal, Powerful others and chance scales and self - concept as measured by the Revised Personal Attribute Inventory.

The treatment involved discussion of six structured moral dilemma stories. Each experimental sub-group had one hour per week discussion session for six weeks. At the end of the treatment sessions, both the experimental group and the control group responded to three questionnaires. The instruments employed were Rests (1974) Defining Issues Test, a measure of principled level of moral judgement, Levenson's (1981) Internal, Powerful other's and chance scales, a measure of locus of control and the Revised Personal Attribute Inventory, a measure of self-concept.

Multivariate Analysis of Variance (MANOVA) statistical method was employed to test hypotheses one, two and three. Hypotheses four, five and six were tested with stepwise multiple regression analysis.

The findings of her study supported hypotheses one, two, four and six, but did not support hypotheses three and five.

Okatahi has demonstrated thd potentiality of the Rest approach in our cultural setting. In the present study the approaches used in Rest Dilemma Stories and the Criterion, measuring devise (the DIT) is to be be tried in the experimental component as the treatment for the group.

2.7: Can Cognitive Style be Shifted Through Training?

On the stability of cognitive styles, Witken et al (1967) expressed the view that cognitive styles are comparatively stable overtime and to a large degree independent of the nature of the information presented to the learner. This view has been criticised by Glaser (1970), who argued that it is the teacher who directs and disciplines students thought processes and so influences their cognitive styles.

A number of literature has been reviewed here to examine the possibility of shifting students cognitive style. Most published works suggest that the construct of cognitive style is teachable.

While approaches to training have always been identified as of paramount importance, relatively little concern has been shown for the part the learner can play in his own learning. The learning strategies used by the learner remain, for the most part, private and subconscious. If learners are to cope with constant retraining then they must be regarded as being instrumental in their own learning. To neglect the importance of the learner in learning is to cast aside a valuable resource potential.

Despite the fact that 'training' receives more attention than 'learning', in recent years there has been a growing interest in the question of helping people to learn how to learn (Rigney, 1978, Bransford,

Stein, Shelton and Owings, 1981, Perry and Downs, 1985). The success of this new impetus rests on whether the "ability to learn" is innate or learned. If individuals are born with a given complement or facility for learning, then perhaps little can be done to help them acquire more effective ways of learning. If this is so, the answer to learning will focus on the best training aids. If however, learning strategies or skills can be improved, then the learner can be introduced to more efficient and appropriate ones.

Many believe that an individual can be helped to develop good ways of learning and as a result there is a growing emphasis on how to learn (process), whereas in the past it was sufficient to assess what had been learned (product), (Rigney, 1978, Bransford et al, 1981). The success of learning rests on many variables.

Perry and Downs (1985) set out to examine what was meant by learning strategies and skills. According to them, strategies, tactics and skills were some of the words used to express the processes of learning. There was no ideal word, but Perry and Downs (1985) decided to select "strategies" to portray the many types of events or processes which take place when learning occured. The skilled learner made appropriate choices not only of media (where applicable) but also of the mental strategies relating to the learning material, for instance, to practise and repeat or question what has been learned.

Furthermore, the learner must be aware of how best to manage resources in order to maximize learning. In doing these, the learner may be said to be skilled at learning or to have good learning "strategies". Rigney (1978) defined learning strategies by referring to them as "those operations or procedures that the student may use to acquire, retain and retrieve different kinds of knowledge and performance". Furthermore, he made a useful distinction between learning or cognitive strategies which are "embedded, and those which are detached". An embedded strategy was not identified independently of the subject matter, in constrast with a 'detached' cognitive strategy. Unless a learning strategy was made overt during a training course, then the strategy may fail to be assimilated by the learner and therefore not be transferred to other learning tasks. When this happens the strategy remains 'embedded' within the subject matter.

Some researchers believe that the traditional way of teaching does little to enhance the development of learning strategies, Knowles (1972) made a distinction between 'knowing how to learn' and 'how to be taught'. He refers to the proactive education system which develops few learning strategies and compares it with reactive systems which encourage many strategies to be developed. Clearly, Knowles emphasized the importance of changing the learning environment in order to bring about a change in the learning strategies demanded. Mumford (1981) sought to make managers

aware of the learning opportunities in the environment by learning consciously and understanding more about their own learning strategies. McCall, Bryce and Robertson (1983) recognized the need to change the way the teacher traditionally assessed students works, from giving global tests at the end of learning to being much more involved in the process of learning, thereby identifying strategies and problems.

Not all learning strategies are expected to be developed by merely changing the learning environment. Some studies focussed on helping learners to identify their own strategies/styles (as in the present study). Gibbs (1981) for instance, found group discussions useful as an initial orientation to students to pay attention to and value their own experiences in learning. Similarly, Perry and Downs (1982) realized the value of learners' experiences. They gave tasks to be learned, then asked for strategies used followed by a group discussion. Learners could then identify new ones and try them out in subsequent tasks.

Howe (1982) stated that those students who could 'summarized' a text had an advantage over those who could not. Reading was found to be more effective for learners who employed a cyclical mode of 'reading to learn', proposed by Harri - Augstein et al. (1982), than those who did not.

From the many studies on learning strategies, there seems adequate evidence that they can be learned and used effectively by learners not only in the training task, but also generalized to other tasks. If the cognitive style is seen in this light, then these previous studies suggest that cognitive style itself can be shifted through training.

Smith and Bramblett (1981) worked on the effect of teachers vagueness terms on students performance in High School Biology. Since vagueness terms appear to represent a global variable that influences achievement across subject areas such as secondary school social studies and mathematics, one might suspect that the use of vagueness terms also would hinder achievement in science. One objective of the study was to determine whether a high frequency of teacher vagueness terms negatively influences learning in high school biology.

A second objective of their research was to determine whether vagueness terms affect student perception of lesson effectiveness in biology. Smith and Land (1980) reported that a high freqnency of teachers vagueness terms in mathematics negatively influenced students perception of lesson effectiveness (and student achievement). However, Smith and Land

administered the achievement test before the perception questionnaire, and they questioned whether the order of administration of these two instruments had a bearing on their results. Therefore Smith and Bramblett's study investigated the effect of teacher vagueness terms on student achievement and student perception of lesson effectiveness, as well as the effect of the order in which the achievement test and the perception questionnaire were administered.

High school biology students (n = 48) were each randomly assigned to one of four groups defined by possible combinations of two teacher vagueness conditions (high vagueness versus low vagueness) and two post - lesson condition (test, then lesson evaluation versus lesson evaluation, then test). Each of the four groups observed a 13 minute videotaped lesson on the vascular system of angiosperms. The only difference in the videotaped lesson was the frequency of vagueness terms. The instructor did not appear on each of the videotapes; only his voice and corresponding overhead transparency projections were taped. Taveggia (1974) reviewed research that indicated there was no significant difference between achievement of students lectured to face-to-face and achievement of students presented videotaped lessons.

Student comprehension of the lesson was determined by administering a 25-item multiple choice and matching test. The items focused on the concepts covered in the lessons. The test was assumed to be valid and reliable since it was based on items in the testing manual that accompanies the student textbook. The students also were administered a 9-item lesson evaluation in which they rated the teacher and lesson on a scale from 1 to 4 points for the following items: (1) The teacher was confident, (2) I was confident of the materials being presented, (3) The teacher was serious about the lesson; (4) The teachers explanations were clear to me; (5) The teacher stayed on the main subject very well; (6) The teacher really knew what he was talking about (7) The teacher did not seem nervous (8) The teacher was prepared; and (9) The teacher did not seem lazy. Smith and Land (1980) reported that this cluster of items enabled students to differentiate significantly between teachers they felt presented clear lessons and teachers they felt presented unclear lessons.

A 2 (low vagueness versus high vagueness) X 2 (post test, then questionnaire versus questionnaire, then post test) analysis of variance was performed on the student achievement score as well as on the lesson evaluation scores. The mean achievement scores

for the four experimental conditions indicates that neither the main effect due to order of post test and evaluation questionnaire nor the interaction between vagueness and order of testing was significant. The vagueness main effect was significant, at $F(1.44) = 5.42$, $P < 0.05$.

Treating each of the nine response items as dependent variables, 2 x 2 analyses of variance indicated that the main effect due to order of testing was not significant for any of the items. The vagueness main effect was significant beyond the 0.05 level for item 1, item 3, item 5, item 6, item 7 and 8. All significant differences were in favour of the low vagueness condition. The only significant interaction ($P < 0.05$) between vagueness and order of testing was for item 7, in which students who were presented the high vagueness lesson perceived the teacher as being more nervous if they responded to the lesson evaluation questionnaire before they took the post test.

The findings of this study indicate that vagueness terms represent a global variable that affects student learning across subject areas including secondary school biology. Infact it bore the contention that a high frequency of vagueness terms causes pupils to perceive the teacher as being unconfident,

disorganized and unprepared, regardless of the substantive content the teacher presents.

It is important to note that in Smith and Bramblett's (1981) study, five vagueness terms occurred in the low vagueness lesson even though the authors intended to eliminate all such terms from that lesson. This illustrates the ease in which vagueness terms are interjected into communication. The authors therefore concluded that if teachers are assisted to acquire more knowledge of the material to be taught, to develop more confidence, and to avoid annoying speech mannerisms, then they would be able to reduce the frequency of vagueness terms below the threshold level at which learning is affected.

Smith and Bramblett's (1981) study had thrown some light on the extent to which the teacher vagueness term do affect students achievement. One may argue that too much of the vagueness terms used led to most students being recallers.

Of particular interest to the present researcher are the facts that Smith and Bramblett employed a 2 x 2 design and analysis of variance on post-test assessments. The subject matter taught was controlled by videorecording the lessons which were delivered by the regular class instructor. The experimental pre-

cautions taken by Smith and Bramblett notwithstanding, some shortcomings of the 2 x 2 factoral desigh have been extensively discussed by Campbell and Stanley (1963). Both authors pointed out that the Solomon 4-group design, which the present researcher plans to use, takes account of external validity factors. By ensuring the equivalents of Experimental and Control groups initially, both the main effects of testing and the interaction of testing and treatment are determinable. The effect of treatment is replicated in four different fashions: $O_2 \rangle O_1$, $O_2 \rangle O_4$, $O_5 \rangle O_6$ and $O_5 \rangle O_3$. By comparing O_6, O_1 and O_3, it is possible to observe the effect of maturation and history, and thus increase the strength of the inference arising therefrom. Smith and Bramblett's experimental design is to be adapted in the present study.

2.8: SUMMARY

From the literature reviewed in this section, the concept of cognitive style has been variously interpreted. Cognitive style has been used simultaneously with Cognitive preference, learning strategies and learning skills. Similarly, the categorization within each concept is varied. These variations notwithstanding, have not eroded the structure and significance

of categories within them. Rather there is a remarkable resemblance (and points of convergence) in the characteristics which describe the various categories. Heath's 4 mode model appears to be particularly useful in the context of science teaching.

Several of the studies point to the statistical significance of the differences in cognitive styles between successful science students and the less successful ones (Kempa and Dube, 1973 Ogunyemi, 1973, Burnette, 1974 and Okebukola, 1984).

In general high achievers tend to exhibit a higher degree of scientific curiousity and lean distinctly towards the pure science side, while low achievers lack scientific curiousity. However Jungwirth (1980) had a different explanation. He asserted that high achievers are so because "they know more than low achievers". That is, they are familiar with more topics and/or have more information/ knowledge at their disposal. The issue he argued, is that of familiarity. If this is so, students who are exposed to a mode of teaching which is consistent with higher cognitive functioning (such as application and questioning) should be expected to exhibit behaviours which are appropriate for these cognitive styles. However, this observation remains to be verified, as it is conceivable that in an experiment

which compares a didactic approach to an application - questioning approach, more contents would be expected to be covered in the former than in the latter.

On the cognitive style of curriculum material, Heath (1964) and Mackay (1972) have demonstrated the variation in cognitive styles between students that used the PSSC literature against the conventional or traditional ones. Omoifo, on the other hand, found similarities between her CESAC and non-CESACs students.

The literature reviewed has also provided insight on the influence of the teacher on his students' cognitive style. The teachers' cognitive style tended to correspond to those of his students, which has been interpreted as some support for the effect of the teachers cognitive style on their students cognitive style.

On the methodological issues and treatment of data, Tamir and Lunnetta compared the relationship between the ipsative and normative systems of responses and found no statistical significant different between the two subtests in R, Q and R-A. The differences between R, A, Q-A were relatively small.

From the many studies on cognitive styles, there seems to be ample evidence to suggest a desired cognitive style that can be taught and learned,

and used effectively by learners not only in the training tasks, but also generalized to other tasks. These studies therefore suggest that cognitive style itself can be shifted through training.

Okatahi (1984) has demonstrated the potentials of the D.I.T. approach for teaching affective attributes in our cultural setting. The D.I.T. has been used by Rest (1974) to assess crucial moral issues in situations involving moral dilemmas. And it is proposed for use in the present study for the treatment class.

CHAPTER 3

Design and Procedure

The present study was partly an attempt to replicate an earlier study on the prevalent cognitive styles among chemistry students and partly to test the possibility of shifting students cognitive styles in a desired direction.

3.1: The Design:

There were four parts to the design of the study:-

(i) There was a paper and pencil chemistry test following a Heath's (1964) model. The test consisted of twenty (20), four options multiple choice items. Each response corresponded to one of Heath's conception of cognitive preference (R, P, Q, A). The stems of the items were diagrams or verbal statements covering the physical, organic and inorganic aspects of School Certificate O-level examinations in chemistry. The distribution of the test-item is shown below:-

HEATH (20-ITEM)

Content	Item Nos.
Physical Chemistry	1,7,8,9,10, 17,19,20
Organic Chemistry	6, 12
Inorganic Chemistry	2,3,4,5,11, 13,14,15, 16,18

DIT (10-ITEM)

Content	Item Nos.
Physical Chemistry	1, 4, 6
Organic Chemistry	-
Inorganic Chemistry	2,3,5,7,8, 9, 10.

Table I

Distribution By Content Area of the Cognitive Preference Test.

(ii) There was another paper and pencil cognitive style test, designed along the Rest (1974) D.I.T. model. It consisted of ten short passages. Each passage presented an issue in chemistry or chemistry context in which respondents were required to take a decision. The issue was presented in a stem, followed by four possible responses, each response corresponded to one of Heath s conception of cognitive preference (R, P, G, A). The use of the D.I.T. approach offers a promising alternative way of re-verifying the existence and distribution of the cognitive style construct. The approach also offers itself readily for teaching effective development as its potency has earlier been demonstrated by Okatahi (1984). These instruments were administered to the students in this study in a pre and post-test design.

(iii) A survey of the teachers perception of their students cognitive styles was carried out using the same instruments and as a confirmation of the students cognitive styles.

The teachers were given two sets (with different colours) of the response sheets for these latter parts. One set was for the teachers to complete about their own cognitive style. For the second set, the teachers were requested to indicate which option (style) per item is likely to be the choice of the majority of his students.

The application of this indirect method should provide further evidence to support the claims of the students. The results of some recent studies suggested that this indirect approach yields definitely different and probably more dependable data from direct observations (Beam and Horvart, 1975; Martins, 1984 and Mahuta, 1986).

(iv) A quasi - experimental set up was used to test the teachability of cognitive styles. The approach used here was similar to that used by Smith and Bramblett (1981). They employed the Solomon 4-way (pre-test, post-test) design as described by Campbell and Stanley (1963). In this design, a randomly selected sample is assigned to one of four groups of an experimental design as follows:-

I. Random Sample: Pretest ------ Post test (C_1)

II. Random Sample: _____ _____ Post test (C_{11})

III. Random Sample: Pretest treatment Post test (E_1)

IV. Random Sample: _____ treatment Post test (E_{11})

For the present study, 69 students in a diploma class were randomly assigned to two main groups, i.e. the experimental and the control groups. These two groups were further sub-divided into two groups. One half of each group had the pretest to conform with the pattern above. Initially, about 100 students had been admitted to this programme and it was planned to assign students equally to the four groups as they arrived. The first 23 students who came into the class the first day were assigned to E_1 and the next 19 students were assigned to C_1 in day I,

then the next 16 students were assigned to E_{II} and the last group of 11 students were assigned to C_{II} in day II.

The main difference between the experimental and the control is that the two experimental classes had three weeks of treatment, whereas the control class had three weeks of normal lectures. At the end of the three weeks, all the groups had the post-test.

In order to reduce external threats to the validity of the observed data, C_{II} and E_{II} were introduced. While C_{II} showed the effect of the pre-test on the subsequent administration of the test (test-wise), E_{II} highlighted the effect of history and other threats.

3.2. The Nature of the Criterion Measure:

In deciding on what criterion to use, the mean cognitive style for about 30 randomly selected chemistry students from the SBS/ABU Zaria were examined in a preliminary study, using ipsative analysis. Results showed that subjects preferences were in the order of Recall (60.93)→ Principles (57.17)→ Application (42.61) → Questioning (41.82). It was found that the greatest difference occured between Recall and Questioning. It was therefore felt that if the treatment was effective, it should be felt most dramatically in the shift from Recall to Questioning. The experimental design model should show the effectiveness of the applied treatment between these two styles. The treatment and its effects were therefore focussed on the change from R→ Q. Thus, if the treatment was effective, not only

would the means of the post-test scores of the experimental sub-groups be greater than the means of the pretest (E_I post-test $>E_I$ pre-test and E_{II} Post-test $>$ C_I pretest) but the means of the post-test for the experimental sub groups should be consistently greater than the means of the post test for the control subgroups (E_I post test $>C_I$ Post test and E_{II} Post-test $>$ C_{II} Post-test). The differences should also be statistically significant.

3.3: Instrumentation

The first instrument was a 20 - item test, based on SBS/ABU entrance examinations over the years 1975-81 and structured to conform to the format suggested by Heath (1964) and Kempa and Dube (1973). The format provides for multiple choice questions with four all correct options. Each option corresponds to one of the four different ways in which students prefer to be taught or the easiest way to remember scientific information i.e, R, P, A, Q. (Shuaibu & Ogunsola, 1983).

A typical item in the test was: Carbon occurs in the free states as diamond and graphite.

a) These are called the allotropes of carbon.

b) These are the two different physical forms of carbon but with the same chemical properties.

c) Diamond is attractive and in great demand for jewelry.

d) There are other non-metals, such as sulphur which exist in free states.

Selection of option (a) adds to the students' recall memory score, while selection of option (b) adds to Principles Score. Option (C) refers to the practical application area and option (d) refers to the critical questioning area.

The second instrument, which was the D.I.T., was a ten item four options, multiple choice test. The stems of the items followed the format of Payette (1967) and Rest (1974), in which a number of passages or situations relating to issues in chemistry, such as Fractional distillation, Hardness of water, Atomic Structure, Boyles law, the Kipps apparatus, Melting of candle wax, writing of Equations, Deliquescent substance, Gases and the allotropes of carbon, which are to be found in the School Certificate O-level examination were presented. Each situation was followed by four possible choices, each choice corresponding to one of Heath's Conception of Cognitive Preference;

a) Recall of Specific facts or memory
b) Practical application
c) Identification of Fundamental Principles
d) Challenging or Critical questioning of information.

Respondents were asked to choose that response which best represents their reaction.

Payette's (1967) approach which is Parallel to Rest's (1974) Defining Issue Test, offers another

means of re-verifying the cognitive style construct and their distribution among the students for the present study.

A corresponding item in the test is as follows:-

THE ALLOTROPES OF CARBON

It's getting to six o'clock this evening and some students decided to go for a stroll around the staff quarters. A few meters from where they started, Jide picked an engagement ring with a diamond stone. They all stopped and had a look at it in turn. Which of the four comments (a - d) is closest to the one you would have made?

"Diamond and Graphite" said Yomi "are the free states in which Carbon occur". Others replied:-

a) They are called the allotropes of carbon.

b) They are the two different physical forms of carbon but with the same chemical properties.

c) Diamond is attractive and in a great demand for jewelry.

d) There are other non-metals, such as sulphur which exist in free states.

The instruments also covers personal data such as students name, teachers name, sex and name of institution.

3.4: Validity and Reliability of the Instruments:

All items in the item pool were submitted to a panel of nine judges to determine whether the item options fit the particular constructs they were written to represent. These judges include four chemistry lecturers (including those that helped in the design of OCST) from chemistry Department A.B.U., Zaria, three chemistry lecturers from Advanced Teachers College and two post-graduate students from the Faculty of Education with a chemistry background. All the judges from the University Department of Chemistry hold doctorate degrees in chemistry and have not less than five years teaching experiences, All the judges from the Advanced Teachers College hold at least a masters degree. The best items were selected after the judges had reacted to them.

All corrections and suggestions were used to modify the final test items which were later given to the students and teachers. Where more than a member of the panel disagrees on a particular item, such an item was replaced with a suggested alternative which was further subjected to the Panel's assessment. When an item received a consensus of agreement among Judges, that item was included in the pool that was administered. At the end of these exercises, the consensus of opinion of the judges was presumed to provide credibility to the claim for face validity of the instruments of this study.

3.4.1 Reliability of the Heath's Model

The instrument used in the present study was adapted from Omoifo's (1986) 20 chemistry sub-test. The 20-item test was itself adapted from the 40-item Ogunsola Cognitive Style test (OCST) for chemistry.

The original OCST was structured to conform to the format of CPT suggested by Heath (1964), Mark (1967) and Kempa and Dube (1973).

The reliability of the instrument was estimated at 0.86 using the split half (odd-even) method. The Cronboch alpha internal consistency coefficient for each style in the instrument (40 item, N=156) was calculated to be R=0.84, P = 0.63, A = 0.54, Q = 0.52. These coefficients are of the order reported by Tamir and Kempa (1977).

Tamir (1985) reported that the original CPT and CCPI tests have reliability coefficients (Cronbach alpha internal consistency test-retest, Split - half and Kuder Richardson 20) of the order of 0.75, 0.67, 0.76, 0.67 for R, P, Q and A respectively, for tests with 40 items and these values were relatively stable with a test in which the test items were not less than 20.

3.4.2: Reliability of the D.I.T. Model

The DIT is a widely used instrument which has been employed in assessing over 100 different samples in four countries (Rest, 1977). In justifying the usefulness of the DIT, Rest stated that this instrument represents:

> .....the most thorough investigation of the homological network of relationships yet conducted of the moral judgement construct, and no other measure of moral judgement has demonstrated such consistently, high reliability and validility involving so many different populations.

Williams (1975) described the DIT as the best available instrument for measuring the extent to which large numbers of students have developed in the direction of giving weight to "the interests of myself.."

Okatahi(1984) reported that tests using the six delemma stories of the type in DIT generally had reliability coefficients of the order of 0.6. With an increased number of such issues, as in the present study, the value should be enhanced.

3.5: The Subjects for the Study

The subjects for the present study include the students and their teachers:-

i) All the chemistry teachers in the College of Agriculture, Samaru and the College of Agriculture and Animal Science, Kaduna, constituted the teacher group. There were three such teachers altogether.

ii) All the chemistry students in the Kaduna College of Agriculture constituted the students group. They were 69 students altogether. Most of these post-secondary

school students had attended a pre-technical course in one of the colleges, where they offered Chemistry in their subject combinations.

3.6: The Procedure:

In a previous study, the School of Basic Studies (SBS) students' cognitive styles were identified (Ogunsola, 1981). In order to obtain further validation of this distribution among post secondary school students, the same procedure was replicated with a different group of chemistry students, using Omoifo's 1986 instrument.

The general class of the College of Agriculture, Kaduna who was studying chemistry as a pre-requisite for their courses was chosen. This class, which was a post-secondary class, was presumed to be the equivalent of SBS. The class is, more amenable to an experimental treatment since the researchers teaches the class. However, group equivalence with the SBS must first be established, and hence the use of Omoifo's instrument in the preliminary study. The results of this preliminary study indicated that most of the students tended to recall and were least inclined to questioning and application in the class-room. This result confirmed Ogunsola (1981) findings.

The pretest was administered in August 1986 during the second week of resumption in the college, after a forced break. About 42 students who were the early arrivals completed the pretest instrument during their normal chemistry period.

The researcher answered all questions requiring clarification. A week later, almost all (69) students had arrived and they were randomly assigned into two major groups, Group E and C. Group E was the experimental class while group C was the control class. In each of these groups, there were those who took the pretest and those who did not.

3.7: Experimental Treatment:

The subject matter taught was controlled by video-recording the lessons, which were delivered by the researcher who was also the regular class instructor. The experimental group was taught in a mode which was geared towards questioning (using the DIT model). For the control group, the usual lecture method was used as much as possible. Both approaches were presented as appropriate, using the video-recorded modes.

The content area covered within the three weeks were:- water impurities and purification; solutions; solubility and solubility curves; osmosis; air composition and fractions of the air that takes part in chemical reaction. These topics were part of the syllabus meant for that term.

For the experimental class, each lesson started usually with a short dilemma story and students were required to listen carefully and respond to the assignment that followed. A typical example from the first lesson on water impurities and purification is given below:-

Sati,who is from a well to do family, has just been transferred to a secondary school far away from home. Unfortunately for her, she arrived in the school when there was water scarcity. She was then directed to a nearby stream where she could get enough water for her washings.

Being Sati's first time of going to such a place, she was naturally excited. But on getting there and seeing the condition of the water, she stood motionless, observing the stream for a few minutes.

Now write down one possible question or reservation you may have if you were Sati.

After a few minutes and on a random basis, some students were selected to read out their questions/ reservations while the teacher writes them on the board. The list of responses included the following:-

1) Why is this water so dirty?
2) Is this the only source of water around here?
3) How can I get rid of the leaves, weeds and other impurities in this water?
4) The water may contain some other insoluble impurities, that I may not be able to see.
5) What happens to the soluble impurities? How can I get them out?

For the first two questions, the students were asked to advance possible reasons for dirty water and to list other sources of water. The acceptable responses were written on the board.

For the last three questions, the students were directed to perform in groups some experiments (typical laboratory exercises) such as filteration, boiling, distillation, etc. which will lead them to get rid of the insoluble and soluble impurities. The teacher went round explaining each step taken to the students and answering students' questions.

Finally, the teacher evaluated the class by asking some questions such as:-

1) List the various sources of water.
2) How can one remove the visible insoluble impurities in water?
3) Suppose I have a sample of sea water which contains dissolved substances, how can I get rid of these?
4) What other type of impurities can we have and how can one get them out?
5) Compare the boiling method to the distillation process as regards removal of impurities.

The acceptable responses were again written on the board which formed the summary of the lesson and notes for the day.

For the control class, the teacher came in and wrote the topic for the day on the board. She introduced the lesson and asked the students to list various sources of water and why some are dirtier than others. The students were given some samples of water to observe and the teacher explained to the students how the observed impurities in each sample can be removed. They were then directed to perform the filtration to

remove the visible impurities, boiling the water to get rid of the tiny living plants and animals that can only be seen using the microscope and distill the water to remove the soluble impurities.

She finally evaluated the lesson using the same type of questions as for the experimental group, and students responses were again written on the board as summary of the lesson and notes for the day.

The whole exercise lasted for three weeks, with a Sallah break in between. A post-test was later administered to all the 69 students, at the end of the three weeks period.

3.8: The Treatment of Data

For each item of the 30-item tests (10 in D.I.T. and 20 in Heath's model), there were four responses. It had already been noted that each of the four responses is scientifically a correct response to its corresponding stem. Thus, the responses yielded ipsative data, since all the responses under each item were equally correct. Students were asked to indicate their preference by allotting four (4) marks to the most preferred option, three (3) to the next, then two (2) and one (1) for the least preferred choice.

In the analysis of data which was done using the computer services of the University, it was found that the data was not normally distributed and the assumptions

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underlying the use of ANOVA were not sustained. Hence the non-parametric statistics was used. A criterion level of 0.05 was set to test the three null hypotheses, namely:

i) The cognitive style distribution among the four classes in the experimental design is not significantly different.

ii) The cognitive style distribution among students is not significantly different from their teachers classification (perception).

iii) The experimental treatment has no significant effect on the cognitive style distribution.

For the first hypothesis, a contingency table for frequency distribution of respondents on the four cognitive styles was set up. The non-parametric X^2-statistic was considered appropriate for this analysis because the data were only frequency counts.

For hypotheses ii and iii, the Mann - Whitney U test was considered appropriate. The U test is used to compare the difference between two population distributions, as an alternative to the parametric t-test. The assumptions underlying the use of the U test are that the two samples are randomly and independently selected, there is an underlying continuous scale of measurement and the scale must be at least ordinal. The U test uses the rank sum. If two distributions of equal size are identical and the

observations from each group are lined up in rank order, from smallest to largest, then the scores from the two groups should be well mixed in that ordered sequence. The number of scores in the first group that precede each of the scores in the second group should equal within sampling error the number of scores in the second group which precede each of the scores in the first group.

The assumption underlying the use of the U test were satisfied in the present study.

The U test was used to compare:-

i) The DIT vs Heath sub-tests;

ii) The teachers perception Vs teachers style;

iii) The teachers perception Vs students style;

iv) The control and the experimental classes.

v) The pretest and the post-test scores.

CHAPTER FOUR

RESULTS, ANALYSES AND DISCUSSIONS

This chapter contains the results, analyses and discussions of data collected from the students and teachers, using the D.I.T. and Heath's instruments.

The former instrument is a ten-item four - optior multiple choice test and the latter is a twenty - item four - option multiple choice test. The test covered all the major areas of chemistry, and subjects were requested to rank all four responses according to their preferences by allotting four marks to the most preferred option, three to the next, then two and one for the least preferred choice. Each option however, corresponded to a different type of cognitive style. The responses yielded ipsative data, because all the responses under each item were equally correct.

Since the major problems were to assess the distribution of cognitive styles among chemistry students using both models (D.I.T. and Heaths) and then attempt to shift the students cognitive styles, the students were divided into two major groups (the experimental and the control groups) as discussed in chapter three. A total of three hypotheses were tested.

4.1: Results and Analyses

The students were randomly assigned to four different groups in order to ensure that group differences were minimal at the start of the experiment.

The first hypothesis tested was that "the cognitive style distribution among the four classes in the experimental design was not significantly different".

To test the first hypothesis, the distribution of subjects per item per cognitive style (Recall, Principles, Application and Questioning) was summed up per sub-test (Heath and D.I.T.) for the 42 students who took the pre-test.

Table II below shows the sums of ratings for each cognitive style for the experimental group (E_1) and the control group (C_1) on the pre-test using the Heath's (20 items) model and the D.I.T. (10 items) tests. The observed frequencies are derived by summing the rating for each style given by $\sum$ students in each sub-group, over 10 items (D.I.T. model) and 20 items (Heath's model) respectively.

Table II: Observed and Expected Frequencies of Responses of the Students in the Experimental and Control Groups (Pretest) (N = 42)

	DIT MODEL (10 items)					HEATH'S MODEL (20 items)			
	Sample Size	R	P	A	Q	R	P	A	Q
E_1 Pre	23	683 (687)	622 (612)	465 (469)	391 (393)	1410 (1427)	1260 (1247)	906 (908)	935 (929)
C_1 Pre	19	595 (591)	516 (526)	408 (404)	341 (339)	1216 (1199)	1034 (1047)	764 (762)	774 (780)
Total	42	1278	1138	873	732	2626	2294	1670	1709
		1.75 : 1.55 : 1.19 : 1				1.57 : 1.37 : 1 : 1.02			
		R > P > A > Q				R > P > Q > A			

In an earlier study of cognitive styles among SBS/ABU students, Shuaibu and Ogunsola (1982) reported that 49 percent of subjects showed preference for recall, 32 percent for principle, 11 percent for application and 8 percent for critical questioning. The general order of preference was R→ P→ A→ Q and the distribution was in the ratio of 5: 3: 1: 1.

From Table II above, the D.I.T. model confirms the direction of the earlier study, although the magnitude of their ratios differ somewhat.

Since the results were frequency counts, the X^2 statistic was employed to assess the independence of the distribution of cognitive styles among subjects.

For the D.I.T. model, the calculated $X^2 = 0.50$ at df = 3 and N = 42. The critical X^2 value was 7.82. The calculated X^2 value was therefore not significant at 0.05 level of confidence. The first hypothesis that there will be no initial difference in cognitive styles between E and C groups, using the D.I.T. model, was supported, confirming group equivalence at the start of the experiment.

For the Heath's model, the result showed that $X^2 = 0.83$ at df = 3 and N = 42. The critical X^2 value was 7.82. The calculated X^2 value was again not significant at 0.05 level of confidence. The first hypothesis of no initial difference in cognitive style distribution using the Heath's model was again supported.

Both sub-tests suggest that at entry, there were probably no group differences in cognitive styles.

In order to confirm the results obtained in Table II, the mean ratings per cognitive style was calculated. Table III shows the mean ratings of the students.

TABLE III

Mean ratings per Cognitive Style for the Experimental (E_1) and Control (C_1) Groups (Pretest)

N = 42

	DIT MODEL						HEATH'S MODEL				
	Sample Size	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	Total	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	Total
E_1 Pre	23	29.70	27.04	20.22	17.00	93.96	61.30	54.78	39.39	40.65	196.12
C_1 Pre	19	31.32	27.16	17.74	14.83	91.05	64.00	54.42	40.21	40.74	199.37
TOTAL		61.02	54.20	37.96	31.83	185.01	125.30	109.20	79.60	81.39	395.49
		$\bar{R} > \bar{P} > \bar{A} > \bar{Q}$					$\bar{R} > \bar{P} > \bar{Q} > \bar{A}$				

For the D.I.T. model, the calculated $X^2 = 0.29$ at df = 3 and N = 42. The critical X^2 value was 7.82. The calculated X^2 value was therefore not significant at 0.05 level of confidence.

For the Heath's model, the X^2 value was 0.07 at df = 3 and N = 42. The calculated value was again not significant at 0.05 level of confidence. This result confirms the results obtained in Table II.

Therefore the first hypothesis that there were no initial differences in cognitive styles between E and C groups, using the D.I.T. and Heath's Model, was supported.

In order to ascertain the distribution of cognitive styles among the students their teachers' perceptions of the students cognitive styles were identified.

The hypothesis tested was that "the cognitive styles of the students as assessed by their preference in the two tests were not significantly different from their cognitive styles as assessed by their teachers".

In order to assess the extent of the influence of the teachers cognitive styles on their students, it was necessary to first assess the teachers cognitive styles.

The teachers were given two sets of the 30-item test (10 for DIT and 20-items Heath's Model). One set was for the teachers to complete about their own cognitive styles (TS) and the second set was for the teachers to indicate how the majority of their students were likely to react to each item (Teachers Perceptions, TP).

The two groups (teachers and students) constitute two independent groups and the measure of their cognitive styles and the teachers perception were ordinal measures, at best. For these reasons, the Mann-Whitney U test was considered appropriate for testing the second hypothesis.

Table IV below shows the analysis obtained using the computer services of Ahmadu Bello University.

TABLE IV

Teachers Perception Versus Experimental Students Cognitive Styles in the Pre-test. (T_P Vs E_1)

	D.I.T. MODEL					HEATH'S MODEL			
	Sample Size	R	P	A	Q	R	P	A	Q
E_1 Pre	23	13.00	12,86	13.90	13.80	12.60	13.30	13.80	14.10
Tp	3	17.20	18.30	18.20	11.50	20.30	15.30	11.20	8.30
U		23.50	18.50	24.50	28.50	14.00	29.00	27.50	20.50
P		0.38	0.20	0.43	0.63	0.10	0.66	0.57	0.26

P gives the probability level at which U becomes significant. Although, there was a remarkable difference in Recall in the Heath's Model, the difference was not significant. From the overall results obtained, the difference in R, P, A and Q styles between the Experimental class that had the Pretest (E_1) and the teachers perception (Tp) was not statistically significant.

Table V below shows the analysis obtained for the teachers perception and the pretest for the control group.

TABLE V

Teachers Perception

Versus Control Group Pretest Scores

	DIT MODEL					HEATH'S MODEL			
	Sample Size	- R	- P	- A	- Q	- R	- P	- A	- Q
C_1 Pre	19	11.10	18.70	12.30	11.80	11.00	11.00	11.90	12.30
TP	3	14.20	16.70	6.30	9.70	14.50	14.50	8.70	6.30
U		20.50	13.00	13.50	23.80	19.50	19.50	20.00	13.00
P		0.44	0.14	0.15	0.60	0.39	0.38	0.41	0.14

From the results obtained above, there was no significant difference between the teachers' perception of their students styles and the students self-demonstrated cognitive styles. Hence the second hypothesis could not be rejected.

A major concern in this study was to find out if students cognitive styles can be modified in a desired direction. Such a change should manifest itself in the effect of the experimental treatment.

The relevant null hypothesis tested was that "the experimental treatment would have no significant effect on the cognitive style distribution".

It is pertinent to note that half of the experimental class (E_1) and Control class (C_1) had a pretest, while the other halves E_{II} and C_{II} did not have the

pretest. This design is consistent with the Solomon 4-group design that was adopted for this present study.

To test the hypothesis, the students in the experimental class went through three weeks of lecture geared towards questioning, while the control class had three weeks of their normal lecture. At the end of the three weeks, a post-test was administered to see the effect of the treatment.

In order to determine the effect of the treatment on the experimental class, the Mann Whitney U-test was used in the paired comparisons.

Table VI below shows the comparison of the experimental pre - and post - tests results.

TABLE VI

Experimental Pretest (E_1 Pre) Versus

Experimental Post test (E_1 Post) Results.

	DIT MODEL					HEATH'S MODEL			
	Sample Size	R	P	A	Q	R	P	A	Q
E_1 Post	23	22.80	25.00	25.00	16.90	21.40	25.50	24.70	25.30
E_1 Pre	23	25.20	22.00	22.00	30.10	25.60	21.50	22.30	21.70
U		225.00	229.00	229.00	112.00	215.50	219.00	236.00	222.00
P		0.38	0.43	0.43	0.01*	0.28	0.32	0.53	0.35

*Significant U at $P < 0.05$

From the results above, there is a significant difference in the Questioning style when E_1 Pre - and post - tests were compared in the D.I.T. Model. There was no such statistical difference for the other styles.

However, the effect of the treatment seems to have increased the preferences for Principles (P) and Application (A) and decreased the mean values for Recall (R) and Questioning (Q). This means that more students were Recallers and Questioners in the pretest than in the post test. This is the reverse of what was expected from the experimental treatment.

The Heath's model showed that there was no statistical difference in cognitive styles between the two groups. However, in this latter model, the mean values for Principles (P), Application (A) and Questioning (Q) increased and the mean value of Recall (R) decreased as would be expected. This shows that the training has some effects on Principles, Application and Questioning, although these gains were not statistically significant.

So the third hypothesis was rejected for the D.I.T. Model as it affected the preference for Q, but could not be rejected for the Heath's Model.

If the treatment had any significant effect, then the superiority of the Experimental group should be evident in E_1 Post) C_1 post - tests. The C_1 post-test should be about equal to C_1 pre-test scores, since the control group has had no treatment and the effect of history over the three weeks treatment period was assumed minimal.

Table VII below shows a comparison of the Experimental (E_1) group post - test scores against the Control (C_1) post-test scores.

TABLE VII

Control Versus Experimental Group

Post - Test Scores

(C_1 Post Vs E_1 Post)

	DIT MODEL					HEATH'S MODEL			
	Sample Size	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
C_1 Post	19	21.80	18.70	25.60	20.00	21.30	19.70	22.50	21.30
E_1 Post	23	21.30	23.30	18.20	22.70	21.20	23.00	20.70	21.30
U		213.50	164.50	141.50	190.50	211.00	184.50	199.00	213.50
P		0.90	0.17	0.05*	0.48	0.85	0.39	0.62	0.90

* Significant U at $P \leq 0.05$

From the results above, there is a significant difference only in Application in the DIT Model. However, the effect of the treatment seems to have increased the preferences for Questioning (Q) and Principles (P) in the DIT Model, and Principles (P) in the Heath's Model. These latter gains however were not statistically significant. So the third hypothesis was rejected for the DIT Model as it affected the preference for A, but could not be rejected for the other cognitive styles and the Heath's Model.

Table VIII below shows the effect of training by comparing the experimental group (E_{II}) post - test scores with control group (C_1) post-test scores.

The E_{II} group did not have the pre-test but the C_I group had the pre-test. If the treatment was effective, E_{II} post-test scores should be significantly and consistently greater than C_I post-test scores.

TABLE VIII

Experimental (E_{II}) Post Test
Versus Control (C_I) Post-test Scores

		D.I.T. MODEL				HEATH'S MODEL			
	Sample Size	R	P	A	Q	R	P	A	Q
E_{II} Post	16	19.10	20.60	16.30	16.10	20.20	15.20	17.30	17.10
C_I Post	19	16.60	15.90	19.40	19.30	16.20	28.30	18.10	18.60
U		124.50	112.50	125.50	126.50	117.50	107.50	150.00	141.50
P		0.36	0.19	0.38	0.40	0.25	0.14	0.95	0.73

From the results in Table VIII above, there is no significant difference between E_{II} and C_I post-test scores in both models. But there is an increase in the mean scores for Recall (R) and Principles (P) in the D.I.T. Model, and Recall (R) only in the Heath's Model. Hence the third hypothesis could not be rejected for both models.

Table IX is an assessment of the effect of testing, by comparing the Experimental group (E_{II}) with the Control group (C_{II}) post-test scores. Both groups did not take the pre-test, but the experimental group had the treatment. Thus, if the treatment was effective, then this should be evident, as the Experimental scores should be greater than the control group scores.

TABLE IX

Control Group (C_{II}) Versus

Experimental Group (E_{II})

Post test Scores.

		D.I.T. MODEL				HEATH'S MODEL			
	Sample Size	R	P	A	Q	R	P	A	Q
E_{II} Post	16	13.00	15.40	15.60	12.60	14.60	12.70	11.50	16.50
C_{II} Post	11	15.10	12.10	11.60	16.10	12.30	15.30	17.60	10.10
U		72.50	66.00	62.00	65.00	75.00	67.00	48.00	48.00
P		0.44	0.27	0.19	0.25	0.52	0.30	0.05*	0.05*

* shows the significant U at P≤0.05

From table IX above, the experimental group means were greater than the control means in Principles (P) and Application (A) in the DIT Model. In the Heath's model, the experimental group scores were greater than the control group scores for Recall (R) and Questioning (Q). A statistically significant difference was obtained in Application (A) in which more of the control students rated this style higher than the experimental students. Another statistically significant difference was recorded with Questioning (Q). However, experimental students rated Questioning (Q) higher than did the control students, as would have been expected. Thus the third hypothesis was rejected for the Heath's model, but could not be rejected for the D.I.T. model.

Table X is a further confirmation of the effect of testing on the control group. If the pretest has had residual effects on the control group (C_I), it should be evident in the pattern of scores of E_{II} post-against C_I pre-test scores. E_{II} post - test scores should evidently be greater than C_I pre - test scores, if the treatment has had any significant effect and the effect of testing is removed. Since the experimental group (E_{II}) had had no pretest but had a treatment before the post - test, any difference between E_{II} and C_I should probably be attributed to the effect of the treatment.

TABLE X

Experimental Group Post test Scores (E_{II})
Versus Control Group Pre-test Scores (C_I)

		D.I.T. MODEL				HEATH'S MODEL			
	Sample Size	- R	- P	- A	- Q	- R	- P	- A	- Q
C_I	19	18.50	15.90	16.90	18.30	18.20	18.90	16.80	16.60
E_{II}	16	17.40	20.40	19.80	12.60	17.70	16.90	19.40	19.70
U		142.50	113.00	130.50	146.00	147.50	134.00	129.50	124.50
P		0.75	0.19	0.47	0.84	0.88	0.55	0.46	0.36

From the results in table X above, there was an increase in the results from C_I to E_{II} for Principles (P) and Application (A) in the D.I.T. model, and an increase in Application (A)and Questioning (Q) in the Heath's model. There was an appreciable difference for Principles under the D.I.T. model, and no significant difference was observed, when the two groups were compared.

Therefore the third hypothesis could not be rejected for both models. Table XI and XII present summaries of the means of post - test scores for the four subgroups, for the D.I.T. and Heath's model respectively.

TABLE XI

Mean Ratings per Cognitive Style of Post - test Scores for E_1, E_{II}, C_I and C_{II} (D.I.T. Model)

	No Treatment					Treatment				
	- R	- P	- A	- Q		- R	- P	- A	- Q	Total
Pre-tested C_I Post	28.68	27.16	23.74	20.58	Pre-tested E_I Post	29.20	28.65	21.22	20.87	200.1
n = 19	(31)	(28)	(23)	(20)	n = 23	(30)	(29)	(22)	(20)	
No Pre-test C_{II} Post n = 11	32.55	27.54	20.91	19.00	No pre-test E_{II} Post n = 16	31.31	29.00	22.00	17.75	199.96
	(31)	(28)	(23)	(20)		(30)	(29)	(22)	(20)	
Total	61.23	54.70	44.65	39.58		60.51	57.65	43.22	28.62	400.06

Comparing the column means in the table above in order to determine the main effects of treatment, it was found that there was a consistent increase in the mean scores for Principles when the experimental groups were compared to the control groups. There was also an increase in the mean scores for Application, when the two groups without pretest were compared. Although these increases were in favour of the experimental group, they were not areas targetted for the experiment. The object

of the experiment was to shift students cognitive styles from predominantly Recall to Questioning. It would seem that the treatment has not been effective for this purpose, with the D.I.T. model.

Although the increase is not consistent with a particular style, the effect of treatment was more pronounced with Principles (P) when the total means were compared (see Table XI).

In comparing the rows to determine the effect of pre - testing, it was observed that there was an increase in the means for Application and Questioning when both control groups were compared with each other. There was a similar increase in the means for Questioning when both experimental groups were compared with each other.

These results suggest that pretesting may have some effect on the Questioning style, suggesting a residual effect of prior knowledge: the more the students know, the more they tend to ask questions. Although this increase has not been shown to be statistically significant, the empirical evidence was supported by the classroom experience and observations of the experimenter. Students tended to ask more questions (consistent with the Questioning Style of Heath) as the experiment progressed.

When the results in Table XI were subjected to further X^2 analysis, the calculated X^2 value was 0.97 at df = 7 and N = 69. The critical X^2 value was 14.07. The calculated X^2 value was therefore not significant at 0.05 level of confidence.

TABLE XII

Mean Ratings per Cognitive style of Post - test Scores for E_I, E_{II}, C_I and C_{II} (Heath's Model)

	No Treatment					Treatment				
	R	P	A	Q		R	P	A	Q	Total
Pre-tested	56.68	55.42	42.74	45.47	Pre-tested	58.33	57.35	40.74	43.70	400.43
C_I Post n = 19	(60)	(55)	(44)	(42)	E_I Post n = 23	(61)	(55)	(41)	(43)	
No pre-test	62.40	55.20	45.10	37.60	No pre-test	63.75	52.69	41.38	41.88	400.00
C_{II} Post n = 11	(60)	(55)	(44)	(42)	E_{II} Post n = 16	(61)	(55)	(41)	(43)	
Total	119.08	110.62	87.84	83.07		122.08	110.04	82.12	85.58	800.43

In comparing the column means to determine the effects of treatment on the Heath's Model, it was found that there were increases in the mean values for Recall

and Principles when C_I post was compared with E_I post. There was a similar increase for Recall and Questioning when C_{II} post was compared with E_{II} post.

In order to determine the effect of pretesting on the Heath's Model, the row means were compared. It was observed that there was an increase in only Questioning when C_{II} post was compared with C_I post - test mean scores. The increases were in Principles and Questioning when E_{II} was compared with E_I post-test mean scores. It should be noted that in these comparisons of means to show the effect of treatment, both Recall and Questioning had an appreciable gain with the experimental groups.

The Heath's model suggests that the treatment that was meant to produce more Questioners tended to produce more recallers and questioners. The D.I.T. on the other hand suggests that the treatment produced more students who now prefer principles.

In both models, for the pretesting, the comparison showed increases in the Questioning styles. This outcome suggests that the pretest may have helped the students more to become Questioners than the treatment administered.

Back in the mid-sixties, Ausubel and Gagné were the foremost proponents of the concept and effects of prior knowledge. Ausubel (1963) has argued that the

provision of appropriate "cognitive structure" is far more important and has a more lasting consequence on what is learnt, than other instructional considerations. His pre-eminent concern is with the ways in which the materials of instruction can be organised to facilitate integration into the learners organised structure of knowledge. These ideas have often been referred to Ausubel's subsumption theory.

Gagne (1968) extended Ausubel's ideas further to include modes of knowledge acquisition in science. Gagne argued that these modes of knowing or intellectual skills were most effectively transferable and were of most permanent worth to the learner. He therefore proceeded to represent the intellectual skills structurally in learning hierarchies. A well articulated learning hierarchy in a topic, according to Gagne, would show in an increasing level of complexity the capabilities that must be acquired as prior knowledge.

It does seem therefore that the exhibition of 'superior cognitive styles' such as questioning and application would require minimally, the Ausubel's prior knowledge at the recall level to serve as advanced organisers. The pretest and the treatment serve this purpose. Few people who do not have the advanced organisers would therefore be expected to be questioners.

4.2: Discussions:

The results in Table II suggest that at entry into the College of Agriculture, there were probably no group differences in cognitive styles among subjects using the D.I.T. and Heath's models of cognitive style tests. The calculated X^2 values of 0.50 and 0.83 for D.I.T. and Heath's respectively which were not statistically significant at 3df confirmed group equivalence at the start of the experiment.

The results also suggested that the College of Agriculture students had higher preference for Recall (R) and Principles (P) than for Application (A) and Questioning (Q) in both models. These results corroborated earlier results which suggest greater preference for R and P (as against A and Q) among Nigerian students at comparable levels of education (Shuaibu and Ogunsola, 1982; Okebukola, 1984 and Omoifo, 1986). This result is also consistent with the results of earlier studies reporting the predominance of teaching styles which encourage Recall and Memorisation in secondary schools in Nigeria (Bajah, 1975; Shuaibu, 1979 and Attah, 1981). Since most of these College of Agriculture students were freshers from the secondary schools, it was not surprising that students will select preferentially a cognitive style test - item which was consistent with the method of instruction with which they were most familiar.

While the order of cognitive preference using the D.I.T. model was R→ P→ A→ Q, students' preferences using the Heath's model was R→ P→ Q→ A, suggesting a tendency for students to choose more of the Questioning style than Application in the model postulated by Heath (1964) and popularised by Tamir (1983). But the order in the D.I.T. model confirms that of an earlier study by Shuaibu and Ogunsola (1982). Tamir and Kempa (1978) also found that Israeli children had a general order of preference of P→R→ A→ Q.

The basic differences between the D.I.T. and Heath's cognitive tests were:-

1) The D.I.T. was a 10-item test, whereas the Heath's model was a 20-item test. (This difference accounted for the larger frequencies in Heath's model than in the D.I.T).

2) The Heath's model was structured to conform with the format suggested by Heath (1964) and Kempa and Dube (1973). The format provides for multiple choice questions with four all correct options. Each option corresponds to one of the four different ways in which students prefer to be taught, that is R, P, A, Q.

Whereas the stems of the items in the DIT followed the format of Payette (1967) and Rest (1974) in which a number of passages or situations relating to issues in chemistry were presented. Each situation was also followed by four possible choices, each choice

corresponding to one of Heath's conception of cognitive preference R, P, A, Q.

Payette's (1967) approach which was popularised by Rest (1974) in his Defining Issue Test, offers another means of re-verifying the cognitive style construct and their distribution among the students for the present study. The approach also offers itself readily for teaching affective development as its potency has earlier been demonstrated by Okatahi (1984).

In order to have an equitable basis for the comparison of the two models, the mean ratings of the students in the experimental class and control class followed by a X^2 analysis were computed for both models (Table III). The calculated X^2 values of 0.29 and 0.07 which were not statistically significant at 3df, suggest that both tests were comparable. It also confirmed group equivalence of the students at the start of the experiment.

The second research problem compared the students cognitive styles (as demonstrated by their responses to two tests) with their teachers' perceptions of the students styles. It is pertinent to note that the number of students was far greater than that of the teachers. This disproportion might be explained by the fact that the College offers chemistry as a remedial course only for two out of the first three terms in the year and as a pre-requisite for students' subsequent courses in agriculture.

The results in Tables IV and V showed no statistical differences between the teachers' perceptions and the students' exhibited cognitive styles in both tests. But it should be noted that an appreciable difference at 0.09 confidence level was obtained for Recall when the experimental sub-group with a pre-test was compared with the teachers' perception in the Heath's model. This difference was however not statistically significant.

In order to confirm the results obtained in Tables IV and V, the mean rating per cognitive style was calculated. Table XIII and XIV show the mean ratings of the students and teachers:

TABLE XIII

Mean Ratings per Cognitive Style for the Teachers Perception versus Experimental Students' Cognitive Style in the Pretest.

N = 26

	DIT MODEL						HEATH'S MODEL				
	Sample Size	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	Total	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	Total
E_1 Pre	23	29.70	27.04	20.22	17.00	93.96	30.65	27.39	19.70	20.33	98.07
Tp	3	33.67	31.33	18.33	16.67	100.00	33.50	29.50	19.17	17.84	100.01
TOTAL		63.37	58.37	38.55	33.67	193.96	64.15	56.89	38.87	38.17	198.08

For the D.I.T. model, the calculated $X_c^2 = 0.47$ at df = 3 and N = 26. The critical X^2 value was 7.82. The calculated X^2 value was therefore not significant at 0.05 level of confidence.

For the Heath's model, the mean scores were halved to place it on the same scale with the D.I.T. The χ^2 value was therefore 0.36 at df = 3 and N = 26. The calculated value was again not significant at 0.05 level of confidence.

This result confirms the results obtained in Table IV.

TABLE XIV

Mean ratings per cognitive style for the Teachers' Perception Versus Control Students cognitive Style in the Pre-test

N = 21

	D.I.T. MODEL						HEATH'S MODEL				
	Sample Size	R	P	A	Q	TOTAL	R	P	A	Q	TOTAL
C_1 Pre	19	31.32	27.16	17.74	14.83	91.05	32.00	27.21	20.10	20.37	99.68
Tp	3	33.67	31.33	18.33	16.67	100	32.50	29.50	19.17	17.84	100.01
TOTAL		64.99	58.49	36.07	31.50	191.05	65.50	56.71	39.27	38.21	199.69

For the D.I.T. model, the calculated χ^2 = 0.08 at df = 3 and N = 21. The critical χ^2 value was 7.82. The calculated χ^2 value was therefore not significant at 0.05 level of confidence.

For the Heath's model, the mean score per style was divided by two to place it on the same scale with the D.I.T. The χ^2 value was 0.32 at df = 3 and N = 21. The critical χ^2 value was 7.82. The calculated χ^2 value was

again not significant at 0.05 level of confidence. This result confirms the results obtained in Table V.

It was suspected that the teachers could be giving information about their own styles (mirroring themselves) rather than their students' styles. To partial out the effect of the teachers own style (TS) on their perceptions of their students' cognitive style (TP), the two groups were compared, using the Mann-Whitney U-test.

Table XV below shows the analysis obtained for these groups.

TABLE XV

Teachers Perceptions of Students Cognitive Style versus Teachers' Own Style (TS)

		D.I.T.				HEATH'S			
	Sample Size	- R	- P	- A	- Q	- R	- P	- A	- Q
TP	3	3.80	3.30	3.70	3.00	3.30	3.30	2.30	2.70
TS	3	3,20	3.70	3.30	4.10	3.70	3.70	4.70	4.30
U		3.50	4.00	4.00	3.00	4.00	4.00	1.00	2.00
P		0.66	0.82	0.82	0.51	0.82	0.83	0.10	0.27

The results in Table XV showed that there were no statistical differences between the teachers perception of students' cognitive styles and the teachers own cognitive styles in both tests. Although an appreciable difference

was found for Application in the Heath's model, there was no statistically significant difference between the teachers cognitive styles and students cognitive styles. This result tallies with Tamir's (1975, 1977) works which provided further insight on the influences of the teachers on the cognitive styles of his students. Tamir found that the differences in the teachers cognitive styles corresponded with those of the students preference patterns. The results may be interpreted as some support for the effect of the teacher on their students.

From the table, it was found that the students and teachers' styles agree most closely on Principles and Application in the D.I.T. and Recall and Principles in the Heath's model. Tamir's results showed also that both the teachers and their classes had a very high preference for Principles ($\bar{X}$ = 112.48, using a rating scale).

In a typical classroom, both the students and the teachers continually interact with the materials of instruction. Thus the cognitive orientation inherent in the instructional materials can also influence the learners' cognitive style.

Omoifo (1986) examined the extent of this influence using the CESAC biology and Chemistry curriculum materials. The results of her study are pertinent to the present study and has been referenced extensively.

Omoifo adapted two parallel Heath's type of tests, consisting of 20 items each in chemistry and biology. The purpose was to find out if CESAC students will demonstrate the same pattern of cognitive styles in biology and chemistry cognitive preference tests. The rating procedure in which the most preferred style was rated four points and the least, one point, was used and this therefore produced ipsative data.

Omoifo also analysed the CESAC text materials using the method of rating to find out the relationship between the cognitive styles of the CESAC materials and the cognitive styles of students who used the materials. The mean cognitive style for both the respondents and the curriculum materials in chemistry and biology were determined by dividing the frequencies per style by the total number of respondents and lesson units in the textual materials respectively.

The theoretical proportion of subjects cognitive styles that would probably be associated with the curriculum materials was assessed, using a χ^2 test of independence. The result showed that there was, no statistical basis to support the hypothesis of the dependence of the two variables. Hence it was concluded that the styles of the CESAC chemistry students were probably independent of the styles implicit in the CESAC chemistry test material. The influence of the CESAC chemistry text book on the students cognitive styles must be minimal.

This was further confirmed by Omoifo's second finding that CESAC and non-CESAC science students admitted into SBS for the 1985/86 session had similar patterns in their cognitive styles. The general trend was R→ P→ A→ Q.

One would have expected that students who used curriculum materials that were purportedly designed to teach enquiry skills, characterised by Q, A and P would show greater preference for these cognitive styles. However, there was no evidence that CESAC curriculum materials had influenced the users' cognitive styles.

The similarity of the subsequent cognitive styles of CESAC and non-CESAC students was hardly surprising. Practically every conceivable advantage claimed for the development of the newer curricula has been a matter of controversy in published works on classroom instruction. In an earlier study, Kanu (1984) demonstrated that users of CESAC and WAEC traditional biology programmes did not differ significantly in their subsequent achievements in a pre-degree (SBS) programme. These findings put the curriculum efforts associated with CESAC to question.

The third research problem was concerned with the possibility of shifting students cognitive styles in a desired direction, through teaching. The preference was from Recall to Questioning. In order to detect the effect of the treatment administered, four sub-groups were compared.

Table VI shows the comparison of the Experimental group (E_I) pre-test and post-test scores. The post-test was administered three weeks after the experimental treatment.

The results obtained showed that there was a significant difference in Questioning style using the DIT approach but there was no such difference in the other styles. The Heath's model did not produce evidence to support the claim that the treatment was effective.

There was an increase in the mean values for Principles (P) and Application (A) in the post-test results of the DIT model and increase in Principles (P), Application (A) and Questioning (Q) in the Heath's model. These increases, except for that in Questioning in the D.I.T. model, were not statistically significant.

In order to confirm the results obtained in Table VI, the mean rating per cognitive style was calculated. Table XVI shows the mean ratings of the students.

TABLE XVI

Mean Ratings per cognitive style of

Experimental (E_1) pre-test and

Post - test Scores.

N = 46

		DIT MODEL					HEATH'S MODEL				
	Sample Size	R	P	A	Q	TOTAL	R	P	A	Q	TOTAL
E_1 Post	23	29.22	28.65	21.22	20.87	99.96	29.18	28.68	20.37	21.85	100.08
E_1 Pre	23	29.70	27.04	20.22	17.00	93.96	30.65	27.39	19.70	20.33	98.07
TOTAL		58.92	55.69	41.44	37.87	193.92	59.83	56.07	40.07	42.18	198.15

For the D.I.T. model, the calculated χ^2 was 0.28 at df = 3 and N = 46. The critical χ^2 value was 7.82. The calculated χ^2 value was therefore not significant at 0.05 level confidence.

For the Heath's model, the mean score per style was halved to place it on the same scale with the D.I.T. The χ^2 value was 0.11 at df = 3 and N = 46. The calculated value was again not significant at 0.05 level of confidence. This result confirms the results obtained in Table VI.

Table VII was also intended to show the effect of the treatment by comparing the Experimental (E_1) group and control (C_1) group post - test scores. Results obtained from the table showed a significant difference for Application in the D.I.T. model but no such difference was observed in the Heath's model. Differences in the mean ratings were noted in Principles (P) and Questioning (Q) between E_1 and C_1 in the DIT approach and in Principles (P) only in the Heath's model respectively. These differences were however not significant. The two sub-groups had the pretest before their post - test. As such, the treatment effect should have been more clearly seen in the E_1 group, if the treatment was really effective. The significant difference obtained with the DIT model in Application raises a fundamental question on the validity of the DIT.

It would seem that the DIT was picking differences where it was not expected to pick such differences.

In order to confirm the results obtained in Table VII, the mean rating per cognitive style was calculated. Table XVII shows the mean ratings of the students.

TABLE XVII

Mean Ratings per Cognitive Style of Experimental Group Versus Control Group Post - Test Scores.

N = 42

		D.I.T. MODEL					HEATH'S MODEL				
	Sample Size	R	P	A	Q	Total	R	P	A	Q	Total
C_1 Post	19	28.68	27.16	23.74	20.58	100.16	28.34	27.71	21.34	22.74	100.13
E_1 Post	23	29.22	28.65	21.22	20.87	99.96	29.18	28.68	20.37	21.87	100.10
TOTAL		57.90	55.81	44.96	41.45	200.12	57.52	56.39	41.71	44.61	200.23

For the D.I.T. model, the calculated χ^2 value was 0.19 at df = 3 and N = 42. The critical χ^2 value was 7.82. The calculated χ^2 value was therefore not significant at 0.05 confidence level.

For the Heath's model, the mean scores were halved to place it on the same scale with the D.I.T. The χ^2 value was 0.07 at df = 3 and N = 42. The calculated value was again not significant at 0.05 level of confidence. This result confirms the results obtained in Table VII.

Results in Table VIII showed the comparison made between the Experimental group (E_{II}) post - test scores with Control group (C_I) post - test scores. The E_{II} group did not have the pretest, but had the treatment and the post - test. The C_I group had the pretest and the post-test but no treatment. So if the treatment was effective, E_{II} post-test scores should be significantly and consistently greater than C_I post - test scores.

The results showed that the E_{II} group had higher mean scores for Recall (R) and Principles (P) in the DIT model and a higher score in Recall only using the Heath's model. An increase for C_I post in Application and Questioning using the DIT and in Principles, Application and Questioning using the Heath's model is suggestive that the pretest may have some residual effects on students cognitive styles. That may be interpreted to mean that the more the teachers repeat a lesson over and over again, the more the students are likely to become "applyers" and "questioners" in Heath's conception. These differences however were not statistically significant.

In order to confirm the results obtained in Table VIII, the mean rating per cognitive style was calculated. Table XVIII shows the mean ratings of the students.

TABLE XVIII

Mean Ratings per Cognitive Style of Experimental (E_{II}) Post Test Versus Control (C_I) Post test Scores.

	DIT MODEL						HEATH'S MODEL				
	Sample Size	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	Total	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	Total
E_{II} Post	16	31.31	29.00	22.00	17.75	100.06	31.88	26.35	20.69	20.94	99.86
C_I Post	19	28.68	27.16	23.74	20.58	100.16	28.34	24.71	21.34	22.74	97.13
TOTAL		59.99	56.16	45.74	38.33	200.22	60.22	51.06	42.03	43.68	196.99

For the D.I.T. model, the calculated X^2 value was 0.45 at df = 3 and N = 35. The critical X^2 value was 7.82. The calculated X^2 value was therefore not significant at 0.05 level of confidence.

For the Heath's model, the mean scores were halved to place it on the same scale with the D.I.T. The X^2 value was 0.31 at df = 3 and N = 35. The calculated value was again not significant at 0.05 level of confidence. This result confirms the results obtained in Table VIII.

Table IX is an assessment of the effect of testing by comparing the Experimental group (E_{II}) with the Control group (C_{II}) post-test scores. Both groups did not take the pre-test, but the experimental group had the treatment. So the effect of the treatment would be evident if the E_{II} group scores were significantly greater than the Control group (C_{II}) scores.

Results from the table showed statistical differences for Application (A) and Questioning (?) in the Heath's model. The difference was in the expected direction in favour of the E_{II} group for only the Questioning score, that is E_{II} post-test > C_{II} post-test scores. This result supports the alternative hypothesis in the Heath's model, but not in the DIT.

This finding further sharpened the fear of the credibility of both tests. Whereas, Heath's model suggested in a most convincing manner that it is possible to shift students' cognitive style, the DIT data had consistently shown an increase towards the Principles (P) scores. It would seem that when students were beginning to prefer more questioning, they were also beginning to prefer recall. These results are inconsistent and would require further examination.

There was a general increase in the means from C_{II} to E_{II} for Principles (P) and Application (A) in the DIT and Recall (R) and Questioning (?) in Heath's model. This result leaves one to wonder if really the pretest had not affected the treatment given. For in cases where a pretest was not administered, treatment seemed to be effective.

In order to confirm the results obtained in Table IX, the mean rating per cognitive style was calculated. Table XIX shows the mean ratings of the students.

TABLE XIX

Mean Ratings per Cognitive Style of Control Group (C_{II}) versus Experimental Group (E_{II}) Post-test Scores.

N = 27

		DIT. MODEL					HEATH'S MODEL				
	Sample Size	R	P	A	Q	TOTAL	R	P	A	Q	TOTAL
E_{II} Post	16	31.31	29.00	22.00	17.75	100.06	31.88	26.35	20.69	20.94	99.86
C_{II} Post	11	32.55	27.54	20.91	19.00	100.00	31.18	27.59	22.54	18.82	100.13
TOTAL		63.86	56.54	42.91	36.75	200.06	63.06	53.94	43.23	39.76	199.99

For the D.I.T. model, the calculated χ^2 value was 0.13 at df = 3 and N = 27. The critical χ^2 value was 7.82. The calculated χ^2 value was therefore not significant at 0.05 level of confidence.

For the Heath's model, the mean scores were halved to place it on the same scale with DIT. The χ^2 value was 0.23 at df = 3 and N = 27. The calculated value was again not significant at 0.05 level of confidence. This result confirms the results obtained in Table IX.

Table X gives a further confirmation of the effect of testing on the Control group. It compared the mean scores of the Experimental (E_{II}) post-test results and Control (C_I) pre-test results. Since the E_{II} group had no pretest, but treatment and post-test, and the C_I group

had pretest no treatment and a post - test, E_{II} post test scores should be greater than C_I pre - test scores, if the treatment has had any significant effect and the effect of testing is removed.

Results from Table X show no significant difference when the two groups were compared using both models. Differences in the mean ratings were noted for Principles (P) and Application (A) in the DIT model and in Application (A) and Questioning (Q) in the Heath's model. There was an appreciable difference for Principles (P) under the DIT model and the difference was in the expected direction, in favour of the E_{II}.

This result further confirmed the results of Table XI and XII. The effect of treatment was more pronounced with Principles (P) when the total means were compared. And for the Heath's model, the effect was evident in Questioning (Q) and Recall (R).

In order to confirm further the results obtained in Table X, the mean rating per cognitive style was calculated. Table XX shows the mean ratings of the students.

TABLE XX

Mean Ratings Per Cognitive Style of Experimental Group Post test Scores (E_{II}) versus Control Group Pretest Scores (C)

N = 35

		DIT MODEL					HEATH'S MODEL				
	Sample Size	R	P	A	Q	Total	R	P	A	Q	Total
E_{II} Post	16	31.31	29.00	22.00	17.75	100.06	31.88	26.75	20.69	20.94	99.86
C_I Pre	19	31.32	27.16	17.74	14.83	91.05	32.00	27.21	20.10	20.37	99.68
TOTAL	=	62.63	56.16	39.74	32.58	191.11	63.88	53.56	40.79	41.31	199.54

For the DIT model, the calculated χ^2 value was 0.35 at df = 3 and N = 35. The critical χ^2 value was 7.82. The calculated χ^2 value was therefore not significant at 0.05 level of confidence.

For the Heath's model, the mean scores were halved to place it on the same scale with DIT. The χ^2 value was 0.03 at df = 3 and N = 35.

The calculated value was again not significant at 0.05 level of confidence. This result further confirms the results obtained in Table X.

Table XXI below shows a summary of the results obtained from tables VI - X. The table shows the relative advantage of the experimental group over the control group as a result of the treatment. Where the treatment had been effective, the experimental scores should be greater than Control scores (E-C = +ve) and where the treatment had not been effective, the control scores should be greater than or equal to the Experimental scores (E - C = -ve or 0).

TABLE XXI

A summary of the Findings on the Effect of Experimental Treatment.

	D.I.T. MODEL				HEATH'S MODEL			
	R	P	A	Q	R	P	A	Q
E_1 Post-E_1 Pre	-ve	-ve	+ve	-ve*	-ve	+ve	+ve	+ve
E_1 Post-C_1 Post	-ve	+ve	-ve*	+ve	-ve	+ve	-ve	0
E_{II} Post-C_1 Post	+ve	+ve	-ve	-ve	+ve	-ve	-ve	-ve
C_{II} Post-C_{II} Post	-ve	+ve	+ve	-ve	+ve	-ve	-ve*	+ve*
E_{II} Post-C_I Pre	-ve	+ve	+ve	-ve	-ve	-ve	+ve	+ve

KEY

-ve means the effect of the treatment is in a negative direction.

+ve means the effect of the treatment is in the desired

positive direction.

O means no effect of treatment.

* indicates where the differences in the mean scores are significant at $P<0.05$.

From the summary in Table XXI it was observed that the Heath's model had proved to be more effective than the DIT model in demonstrating a shift in cognitive style from Recall to Questioning. Out of the five sub-groups compared, it was only when E_{II} post was compared with C_I post that the effect of the treatment was negative for the Questioning style. For E_1 Post test and C_1 Post - test scores, there were no differences in their mean ratings on the Questioning scores. There were differences in the mean ratings of the other four comparisons. In fact, a significant difference was observed in the case of E_{II} versus C_{II} Post - test scores. For the D.I.T. model, the expected difference in favour of the experimental group was obtained only when E_I Post-test was compared with C_I Post - test scores. The DIT data has consistently shown a shift towards the Principles scores, whereas the Heath's model suggested in a convincing manner the possibility of shifting students cognitive styles from predominantly Recall (R) to Questioning (Q).

Since some of the results obtained earlier raised fundamental questions on the validity of the models, it was necessary to have a preliminary comparison of the DIT and Heath's model.

Tables XXII a - f below show the comparisons within each subgroup of the DIT and Heath's model. The purpose was to determine the extent of agreement between the two tests.

TABLE XXII

Preliminary Comparison of the DIT and Heath's Models.

a) C_I Pre (n = 19)

	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
DIT	19.30	19.90	22.10	15.70
Heath	19.70	19.10	16.90	23.30
U	177.50	172.00	13.10	108.50
P	0.93	0.80	0.15	0.03*

b) C_I Post (N = 19)

	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
DIT	20.00	18.50	23.00	16.90
Heath	19.10	20.50	16.10	22.00
U	171.50	162.00	114.50	130.50
P	0.70	0.59	0.05*	0.14

c) E_I Pre (n = 23)

	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
DIT	24.00	24.30	24.20	15.80
Heath	23.00	22.70	22.80	31.20
U	252.00	245.50	248.50	86.50
P	0.78	0.68	0.72	0.0001*

d) E_I Post (n = 23)

	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
DIT	23.60	24.20	24.80	21.30
Heath	23.40	22.80	22.20	25.70
U	261.50	248.00	235.00	215.00
P	0.95	0.72	0.52	0.28

e) E_{II} Post(n = 16)

	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
DIT	16.00	20.10	19.00	11.80
Heath	17.10	12.30	14.10	21.20
U	119.50	71.00	88.00	53.80
P	0.75	0.03*	0.13	0.005*

f) C_{II} Post (n = 11)

	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
DIT	13.20	11.50	9.40	11.80
Heath	9.80	11.50	13.60	11.20
U	41.50	60.00	37.50	57.00
P	0.21	0.97	0.13	0.82

* Significant U at $P<0.05$.

From the results obtained in Tables XXII (a - f) where the two tests were compared, significant differences were observed in the mean ratings for Questioning (Q) in a, c, and e above. For the control (C_I) Post-test (b), a significant difference was observed in the mean rating for Application. No such difference was observed for the E_I Post-test (d) and C_{II} Post test (f) results.

When the two models were compared in the Experimental E_I pretest and E_{II} post-test scores, the significant difference was in the Questioning.

The results of these comparisons provide the evidence to support the observation that the sensitivities of both tests were not the same. Indeed, the Heath's model appears to be more consistent than the D.I.T. model.

From the results obtained in Table IX earlier, there was another possibility of the pre-test having an effect on students cognitive style. In order to produce further evidence to support this claim, comparisons were made among sub-groups of those who had the pretest and those that did not have the Pretest.

Table XXIII below shows the effect of Pre-testing by comparing Experimental (E_{II}) and (E_I) Post-test scores. The Experimental (E_{II}) group had no pretest but the Experimental (E_I) group had the Pretest. Both groups

had the treatment and the Post - test. So, if the pretest had an effect, then the mean ratings for E_I (which had a Pre-test) should evidently be greater than E_{II} mean scores.

TABLE XXIII

A Comparison of Experimental (E_{II}) and (E_I) Post-test Scores.

	DIT MODEL					HEATH'S MODEL			
	Sample Size	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
E_I Post	23	18.10	20.10	18.50	23.10	17.30	23.70	19.60	19.90
E_{II} Post	16	22.90	20.00	22.00	15.30	23.30	14.30	20.50	20.10
U		137.70	183.50	151.50	109.50	121.00	100.00	174.50	182.00
P		0.18	0.99	0.35	0.03*	0.07	0.02*	0.79	0.95

* Significant U at $P \leq 0.05$

From the results obtained in Table XXIII there were significant differences in Questioning, using the DIT, and in Principles using the Heath's model. Experimental group (E_I) mean scores were greater than Experimental group (E_{II}) mean scores in Principles (P) and Questioning (Q) for the DIT, and in Principles (P) only for the Heath's model. These results suggest that the styles most affected by the Pretest, using these two models are Questioning (Q) and Principles (P).

Table XXIV compared the Control (C_{II}) group Post - test results with the Control group (C_I) Post - test results. The latter had a pretest before the post test and the former (C_{II}) had not taken the pretest, but had only the Post - test. Both groups had no treatment. If the Pretest has had an effect, then the means for the Control (C_I) group should be greater than the Control (C_{II}) group means.

TABLE XXIV

Effect of Pretesting Using the Post-test Results of the Control Groups (C_I and C_{II})

		DIT MODEL				HEATH'S MODEL			
	Sample Size	- R	- P	- A	- Q	- R	- P	- A	- Q
C_I Post	19	13.70	15.10	17.70	15.70	14.70	15.80	14.10	18.10
C_{II} Post	11	18.60	16.20	11.70	15.20	17.10	15.10	17.00	11.10
U		70.00	97.00	63.80	101.00	88.50	99.00	78.50	55.00
P		0.14	0.75	0.07	0.88	0.49	0.81	0.26	0.03*

* Significant U at $P \leq 0.05$

From the results of table XXIV above, the means of the Control group (C_I) were greater than those of the Control group (C_{II}) in Application (A) and Questioning (Q) using the DIT model, and in Principles (P) and Questioning (Q) using the Heath's model. A significant difference was obtained for Questioning using the Heath's model. This result, though

not exactly the same as what was obtained from Table XXIII, has also demonstrated the effect of pretesting on the Questioning (Q) and Principles (P) styles.

Table XYv also dealt with the pretest effect by comparing the post-test scores of the Experimental group (E_I) and the Control group (C_{II}). The Experimental group had a Pretest with treatment before a post-test, whereas the control group had no pretest and no treatment, but had a Post - test. So, if the Pretest and treatment should have an effect, the mean scores for the Experimental group should be greater than the Control group (E_I) C_{II}).

TABLE XXV

Effect of Pretesting using the Post-test Scores of the Experimental (E_I) and Control (C_{II}) Groups.

	DIT MODEL					HEATH'S MODEL			
	Sample Size	- R	- P	- A	- Q	- R	- P	- A	- Q
E_I Post	23	15.00	18.70	17.70	18.50	16.20	18.70	15.40	20.30
C_{II} Post	11	22.70	15.10	17.10	15.50	20.30	15.10	22.10	11.70
U		69.50	98.50	22.50	104.00	96.00	98.50	77.50	63.00
P		0.04*	0.31	0.88	0.40	0.26	0.30	0.07	0.02*

* Significant U level at P(0.05

The results obtained above suggest that the pretest had some effects on Principles (P) and Questioning (Q) using the Heath's model and Principles (P). Application (A) and Questioning (Q) using the DIT model. This result tends to agree with that obtained with the Control group (see Table XXIV). And in all the three cases considered so far. Principles (P) and Questioning (Q) have consistently been affected by Pretesting.

TABLE XXVI

Effect of Pretesting by Comparing Control Group Pre and Post-test Scores.

	DIT MODEL					HEATH'S MODEL			
	Sample Size	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$	$\bar{R}$	$\bar{P}$	$\bar{A}$	$\bar{Q}$
C_I Post	19	21.40	19.80	16.90	18.10	21.90	18.20	18.30	17.40
C_I Pre	19	17.60	19.20	22.10	20.30	17.70	20.30	20.70	21.50
U		145.80	175.80	131.50	153.00	134.00	156.00	158.50	140.50
P		0.30	0.87	0.15	0.42	0.17	0.47	0.52	0.24

From the result obtained above, the pretest effect could be observed in Recall and Principles scores for the DIT and Recall only using the Heath's model. This result is quite different from the ones that had been obtained so far, since in the former three tables, XXIII, XXIV and XXV, there had been no pretest effect on the

Recall style. But the four tables suggest that the effect of the Pretest is consistently on the mean scores for Principles in both models. And three of the tables suggest the effect of the Pretest is on the mean scores for Questioning. It is important to note that the effect of Pretesting on Questioning is greater in the DIT model than in the Heath's model.

This result suggests that the more the students know, the more they question and search for the underlying Principles.

CHAPTER FIVE

Summary, Generalisations and Recommendations.

5:1 SUMMARY

This study was an attempt to replicate an earlier study on the prevalent cognitive styles among comparable pre-degree students in Zaria, Nigeria. The subjects were Ahmadu Bello University College of Agriculture, General class (1985/86) students. The students cognitive styles were examined in relation to their teachers perception of their students cognitive styles. The possibility of shifting students cognitive styles in a desired direction was also tested.

A total of three hypotheses were tested, namely:

(i) The cognitive style distributions among the four classes in the experimental design were not significantly different.

(ii) The cognitive style distributions among students was not significantly different from their teachers perception of their (students) styles.

(iii) The experimental treatment has no significant effect on the cognitive style distribution of students.

A 30 - item (10 items of DIT and 20 items of Heath's Model) test instrument, covering all the major areas of chemistry was designed with four equally plausible and correct options. The DIT instrument followed the pattern

suggested by Payette (1967) and Rest (1974) and was employed by Okatahi (1984) in Nigerian situations. The 20 - item sub-test followed the format suggested by Heath (1964) and has been employed by several others.

These instruments were validated by nine judges, made up of chemists and science educators, to ascertain that the stems were valid statements in chemistry and that the options were equally correct and plausible.

In this study, a class of about seventy students were randomly assigned to two main groups, i.e. the experimental and the control groups. These two groups were further sub-divided into two, in which one half had the pretest to conform with the Solomon 4-way (Pre-test, Post-test control group) design as described by Campbell and Stanley (1963).

To test the first hypothesis, the frequency counts and mean scores were analysed separately using the χ^2 statistics for the experimental and control groups pretest scores. This was to find out if there was group equivalence at the start of the work.

The results in Table II showed that at entry into the College of Agriculture, there were probably no group difference in cognitive styles among subjects using the D.I.T. and Heath's model of cognitive styles tests.

The calculated X^2 values of 0.50 for the DIT and 0.83 for the Heath's model which were not statistically significant at 3df confirmed group equivalence at the start of the experiment.

Table III confirmed these results when the mean scores per cognitive style was compared. The X^2 value was found to be 0.07 using the Heath's model and 0.29 using the D.I.T. The critical X^2 value was 7.82. Therefore, the calculated X^2 value was not significant at 0.05 level of confidence. The first hypothesis of no difference in the four classes of the experimental design, was therefore supported.

It was worth noting here, that the D.I.T. model confirms the earlier direction established by Shuaibu and Ogunsola (1982), R→ P→ A→ Q, although not in the same ratio.

For the second hypothesis, the Mann-Whitney U test was considered appropriate for testing the teachers perception against the students style. Results from Tables IV and V revealed that there was no significant difference in the teachers assessment of their students cognitive style and the students assessment of their cognitive styles, using the D.I.T. and Heath's models. Hence the second null hypothesis could not be rejected.

A major problem of this study is concerned with the possibility of shifting students cognitive styles from a predominantly recall style to questioning. The Mann-Whitney U - test was used to compare various sub-groups that had the treatment against those that had not.

When the Experimental (E_I) Pretest scores were compared with the Post - test scores (Table VI), it was found that there was a significant difference in the Questioning style, using the D.I.T. instrument. But the difference observed was in the reverse direction. That is, the students tended to question more before the treatment than after the treatment. For the Heath's model, there was no such statistical difference in cognitive style between the two sub-groups.

On the other hand, when the Post test scores for the Experimental (E_1) and control (C_1) groups were compared (Table VII), there was a significant difference in Application and the difference was in the negative direction. This means that the students were more "applyers" before the treatment than after using the D.I.T. instrument. There was no significant difference using the Heath's model.

When the Control (C_I) group and Experimental (E_{II}) group Post-test scores were compared, there was no significant difference between E_{II} and C_I post test

scores, using both models (Table VIII).

The effect of testing was assessed by comparing the Experimental group (E_{II}) with the Control group (C_{II}) Post test scores (Table IX). A statistical difference was obtained in Application and Questioning, using the Heath's model. There was no such difference using the D.I.T. model.

To further confirm this result, the control group (C_I) pretest and Experimental group (E_{II}) post test scores were compared. There was an appreciable difference for Principles using the D.I.T. and no significant difference was observed when the two groups were compared.

Finally the mean scores for the four styles were considered under treatment versus no treatment and Pretest versus no Pretest (2 x 2) contingency table per instrument. The X^2 statistics was used to analyse this table. The calculated X^2 value for the D.I.T. was 0.97 at df = 7 and N = 69. The critical X^2 value was 14.07. The calculated X^2 value was therefore not significant at 0.05 level of confidence. So the third hypothesis that the experimental treatment has no significant effect on cognitive style distribution was supported by the D.I.T. model.

For the Heath's model, the calculated χ^2 value was 1.35 at df = 7. Since the critical value is 14.07, the third hypothesis was again supported by the Heath's model.

From the results obtained so far, it may be concluded that (1) The College of Agriculture students have a comparable pattern of cognitive styles with their SBS/ABU counterparts, showing a greater preference for recall style than any other style. The relative proportions of the distributions however differ with Agric. students exhibiting greater proportion of Application and Questioning styles than S.B.S. students.
(2) It is possible to shift students cognitive styles from predominantly recall to a more even distribution of cognitive style on the 4-mode model of Heath, using an instructional strategy that emphasizes Questioning.
(3) Between the criterion measures, the Heath's model proved to be more consistent than the D.I.T, in demonstrating a shift in cognitive style from Recall to Questioning.

5.2: Limitations of the Study

A number of problems and limitations associated with this study, particularly with respect to the sources of data and the method used, has been noted.

1. The National Education Technical Centre (N.E.T.C.) professional and technical services who did the video recording, did not have the facility for video recording straight into a VHS cassette of two to three hours duration. They had to make use of their KC 20 and 30 minutes cassettes, which are limited in number. So the researcher had to hurry through the lessons to last either 20 or 30 minutes duration, depending on the availability of the cassettes on each recording. Since the study was severely limited by fund, the researcher could not purchase these cassettes herself. This short duration of the video recorded lessons may not provide the students enough time for a change in their styles.
2. There were not enough apparatus for the students to perform their experiments while receiving instructions from the video programme. Students had to perform the experiment in small groups. As a result, students were unable to concentrate on the programme and could therefore not exhibit satisfactorily, behaviours that were consistent with inquiry and discovery learning.
3. Since the students did not know the relevance of their being divided into four sub-groups during the experimental stage, some of them that missed their own group lessons joined other groups. Although the researcher tried sending some of these students out, there may have been other students who succeeded in

moving from one sub-group to another during the lessons. The mere fact that the students were assigned into different groups may have encouraged some out-of-class interaction which in turn may affect the outcome of the study. Also for those students that missed a lesson or two from their sub-groups, they may have been affected by not having enough lessons to bring about any change. Thus intact groups in the Solomon 4-way design was not possible and the resultant interaction could have polluted the outcome of the experimental study part.

4. There were days that the programme planned had to be postponed because there was no light in the school. There was also a forced Sallah break between the programme. These breaks may have affected the students continued thought processes. So that by the time they were watching another programme after a break, it was likely that they may have forgotten everything about the previous programme.

5. The three weeks training period may not have been sufficient to change a style and sustain it. Although Okatahi (1984) showed that two weeks may be enough for a training for a change in attitude, such a change may not be sustained. A sustained change in attitude requires a longer period.

6. The teachers were given a time limit during which they were to complete the test items on their cognitive styles and their perceptions of their students cognitive style. It is therefore possible for some of the teachers to discuss among themselves, how to tackle the assignment. If this happens, then teachers are more likely to give similar responses to their students cognitive styles.

7. Only three teachers were involved in this study due to the fact that chemistry is not a major course but taught as a prerequisite to the agriculture courses in the colleges. The results obtained for the teachers should have been strengthened with more teachers involved.

8. The D.I.T. instrument used did not cover the organic aspect of chemistry. Although this is not the main instrument used for the study, but a fair coverage of all the aspects should have been important.

5.3. Generalisations.

Within the limitations of the present study, the following generalisations may be made:-

1. The subjects of this study have a comparable pattern of cognitive styles with their SBS/ABU counterparts, showing a greater preference for Recall style than any other style. The relative proportions of this distribution however differ.

2. The experimental treatment has little or no effect on shifting the chemistry students cognitive styles from a predominantly recall to questioning.

5.4: Recommendations

One of the obvious requirements after an investigation of this kind is to replicate the study to a different group of subjects. Such a replication not only strenghthens the validity of any findings which occur on both occasions, but also enables further consideration of some doubtful issues. In the current study, the findings with respect to two hypotheses were inconclusive and a replication should be aimed particularly at clarifying these issues.

From the results obtained in this study, the following recommendations are made:-

The results obtained for the first research problem suggest that the College of Agriculture students had higher preference for Recall (R) and Principles (P) than for Application (A) and Questioning (Q). One would have expected students from a vocational institution such as a College of Agriculture to be more inclined to apply. This unexpected results from the agriculture students may be due to the fact that the teachers teach mainly for Recall and Principles.

Results obtained from the second research problems and table XV provided further insight on the influences of the teacher on the cognitive styles of his students. It was found that the students and teachers styles agree most closely on Principles and Application in the D.I.T. and Recall and Principles in the Heath's model. These results may be interpreted as some support for the effect of the teacher on their students. But an important characteristic of the new science curriculum has been an increased emphasis on concept formation, scientific principles, inquiry processes and critical thinking. Implicit in the new science curriculum is the assumption that the teacher and the way he deals with the curriculum may direct and discipline students' thought processes and so influence their cognitive styles. Teachers should therefore vary their instructional methods to conform with thenew science objectives.

The last research problem dealt with the possibility of shifting the students cognitive styles from Recall to Questioning through teaching. The D.I.T. data consistently show a shift towards the Principles scores, whereas the Heath's model suggested the possibility of shifting students cognitive styles from predominantly Recall (R decreased from 18.20 to 17.70) to Questioning Q (Q increased from 16.60 to 19.70). See Table X.

When the two tests were compared, it was found that the sensitivities of both tests were not the same. More experts in chemistry may have to re-examine the two tests instruments since the results from the two are inconsistent.

For further studies:-

It is recommended that future studies should focus on the following:-

1. The experimental treatment should be extended over a longer period without break. This will allow for enough time perhaps, for an observable change to take place.
2. Modes of data gathering and treatment should be further reviewed in subsequent studies. Teachers should not be allowed to take their test items away to be filled to avoid discussions among themselves, and the time for each lesson meant for the treatment should be extended to the normal school period of 45 to 50 minutes.
3. Although it has been found that it is possible to shift students cognitive style, future studies should help to validate this.
4. It seemed from the results obtained that when students were beginning to prefer questioning, they were also beginning to prefer recall. These results are inconsistent and would require further examination.

5. The number of teachers in the present study is too small compared to the number of students. The ratio should be increased in future studies.

6. Campbell Design 6 may probably have been more appropriate here, since intact groups in the Solomon 4-way design was not possible with the present study. A post test only control group design will eliminate the effect of pre-testing.

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APPENDIX I

TEACHERS PERCEPTION OF STUDENTS COGNITIVE STYLES

Name of Teacher_____

Class_____

Name of College_____

State Located_____

INSTRUCTION

This instrument is designed to find out how your students are most likely to react when confronted with chemistry problems. The interest is not in whether students can identify correct or incorrect information, but rather in what they are likely to do with the information (problem) intellectually.

For each of the situations presented are four possible responses, each corresponding to one of Heath's conception of cognitive preference (Recall, Principle, Application and Questioning). The behaviours which are appropriate for each of these cognitive preference mode are as follows:-

Recall (R) The students will prefer the basic information as read from the textbooks or as dictated by the teacher and accepts it with little or no questions. They tend to memorise this information.

Principle (P) They try to look for the trend (pattern) involved and conditions under which certain things happen.

Application(A) They concern themselves with the social and scientific utility of the concept.

Questioning(Q) They desire to know the circumstances under which the information holds true and the exceptions to this rule. They quite often try to generalize.

Each option of the following items reflects one of these categories.

Please indicate how on the average your chemistry students tend to respond to each situation. You will indicate this by allotting four (4) marks to the option that best describes the type of information (s) they will prefer you to give them, three (3) to the next, then two (2) and one (1) mark to their least preferred choice.

Thanks for your co-operation.

M. F. Bandele.

APPENDIX II

TEACHER'S COGNITIVE PREFERENCE TEST INSTRUCTION

NAME:-

SEX:-

NAME OF COLLEGE:-

STATE LOCATED:-

INSTRUCTION

This chemistry test is conducted so that we may know the way you think and are likely to pass the chemistry information to your students.

It is recognised that in one lesson, a teacher may say all of the options, but we are interested in which option will receive your greatest emphasis. You will indicate your preference by allotting four (4) marks to the most preferred option, three (3) to the next, then two (2) and one (1) to the least preferred choice.

Thanks for your co-operation.

M. F. Bandele.

APPENDIX III

STUDENT'S COGNITIVE PREFERENCE TEST INSTRUCTION

NAME:-

SEX:-

GROUP:-

NAME OF COLLEGE:-

STATE LOCATED:-

INSTRUCTION

This chemistry test is conducted so that we may know the way you think about chemistry statements. It is not a test of how much you know, but of what type of information you will prefer your teacher to teach you. You will indicate your preference by allotting four (4) marks to the most preferred option three (3) to the next, then two (2), and one (1) for the least preferred choice.

Please note that ALL the responses under each item are equally correct. you are assured that your response will not be used against you. You should therefore feel free to indicate the option in order which you truly prefer them.

Thanks for your cooperation.

M. F. BANDELE

APPENDIX IV

COGNITIVE PREFERENCE TEST USING HEATH'S APPROACH

1. In the electrolysis of copper II sulphate solution using platinum electrodes, copper ions are preferentially discharged at the cathode.

   (a) Copper coated plates are produced in this way
   (b) Hydroxyl ions are also discharged at the anode
   (c) Concentration may affect the preferential discharge of copper ions
   (d) When two or more ions of similar charges and under similar conditions are present in solution, one is preferentially discharged due to its position on the electrochemical series.

2. Carbon occurs in the free states as diamond and graphite.

   (a) These are called the allotropes of carbon
   (b) These are the two different physical forms of carbon but with the same chemical properties.
   (c) Diamond is attractive and in great demand for jewelry.
   (d) There are other non-metals, such as sulphur which exist in free states.

3. Zinc usually reacts with dilute non-oxidising acids

   (a) All metals above hydrogen in the electro-chemical series theoretically react with dilute non-oxidising acids to produce hydrogen.

   (b) Hydrogen is produced.

   (c) Peanut and coconut oils may be "hardened" when hydrogen gas is blown into them.

   (d) Some other metals should similarly react with all dilute non-oxidising acids to produce the same type of gas.

4. Carbon dioxide turns lime water milky.

   (a) This explains the reaction of white wash in the atmosphere.

   (b) This is a way of identifying carbon dioxide.

   (c) Calcium carbonate is produced since carbon dioxide is acting as an acid.

   (d) Excess carbon dioxide may turn lime water colourless.

5. Hydrogen peroxide is decomposed rapidly at room temperature in the presence of manganese (IV) oxide.

   (a) The gas produced is oxygen

   (b) Manganese (IV) oxide is one of such substances which alter the rate of chemical reaction without themselves undergoing a chemical change.

   (c) The gas produced may be obtained in smaller quantities in the laboratory by heating some other solids.

   (d) Large quantities of the gas produced may be applied to accident patients in short supply of the gas.

6. One mole of methyl alcohol is dissolved in enough water to make one liter of solution.

   (a) Such a solution will have a lower freezing point than that of pure water.

   (b) One mole of any other alcohol may dissolve in enough water to make one liter of solution.

   (c) The solution could be used as an anti-freeze.

   (d) The solution is known as a molar solution.

7. Some substances expand upon going from liquid to the solid phase.

   (a) Water is an example of such a substance.

   (b) The statement implies that geometrical spacing among molecules may change during a phase change.

   (c) This explains why water pipes burst during extremely cold weather when water is frozen.

   (d) The statement leaves one wondering if most or only a few substances behave in this way.

8. Solid carbon dioxide (dry ice) changes directly into carbon dioxide gas without melting at 78°C.

   (a) This phenomenon is used for cooling foodstuff

   (b) This is a process of sublimation.

   (c) The phenomenon sublimation, is due to the weak intermolecular forces in carbon dioxide.

   (d) Since not all substances may undergo sublimation, this may be an effective method of purification.

9. At a given temperature, the volume of a given mass or dry gas is inversely proportional to the pressure.

   (a) The statement refers to Boyle's law.

   (b) This explains why a balloon floats in the air.

   (c) When the volume decreases intermolecular distance decreases and the rate of bombardment on the sides of the container increases.

   (d) One wonders if the addition of more gas to a fixed volume of gas at a given temperature would also not increase the pressure.

10. When water is cooled it freezes to ice and when ice is heated, it changes back to water.

   (a) This is a physical change.

   (b) Rusting of iron is not a change of the type associated with the statement.

   (c) A change in state may involve changing from solid to liquid to gas or a change in physical form e.g. colour or shape.

   (d) This explains the heating of glass to various shapes.

11. The Electronic structure of the oxygen atom is



   (a) Oxgen is in the 2nd period so the K shell is full with 2 electrons, also it is in the 6th group, therefore there are six electrons in the L. shell.

   (b) The oxygen atom has eight electrons.

   (c) The electronic structure of the oxygen atom determines the reactivity of this atom.

   (d) With one electron added, the electronic structure of another gas may be deduced.

12. Alkanes are the simplest type of hydrocarbons.

    (a) These are organic compounds containing only hydrogen and carbon with a general formular C_nH_{2n+2}

    (b) Methane is the first member of the group.

    (c) Alkanes occur as products of the decay of vegetables.

    (d) Alkenes are also hydrocarbons.

13. Air contains quite a number of gases.

    (a) Nitrogen has the greatest percentage.

    (b) Air is a mixture and the properties of air includes the sum of the properties of these gases.

    (c) Most of the gases are useful to plants and animals.

    (d) Air also contains impurities.

14. Some substances absorb water on being exposed to air.

    (a) This explains why pellets of sodium hydroxide kept outside in a watch glass appear to have melted.

    (b) Above substances are called deliquescent substances.

    (c) Because of evaporation of lakes, oceans, seas and rivers, the air contains water vapour which these substances absorb.

    (d) Hygroscopic substances also absorb moisture from the atmosphere.

15. It is possible to have hard water which will not readily form lather with soap.

    (a) The presence of soluble metallic salts like hydrogen carbonates (Bicarbonates), sulphates and chlorides of calcium magnesium and iron will prevent the formation of lather with soap.

(b) One type of hardness is temporary.

(c) Hard water is desirable in beer industry.

(d) Hard water may be softened.

16. Oxygen and nitrogen can be obtained industrially from liquid air.

(a) Nitrogen will boil off first at - 196°C leaving liquid oxygen.

(b) This can be done using fractional distillation.

(c) The two gases can also be prepared using chemicals in the laboratory.

(d) Both gases are useful to both plants and animals.

17. Purely covalent compounds are not electrolytes.

(a) They do not conduct electricity at all.

(b) However there are some covalent compounds which become ionic when dissolved in water and so they conduct electricity.

(c) This explains why rubber is used in preventing shock.

(d) Covalent compounds usually exist as molecules and are composed mainly of non-metallic elements joined together.

18. The salt formed from sodium hydroxide and hydrochloric acid is called sodium chloride.

(a) Formula of sodium chloride is Nacl.

(b) An alkali usually reacts with an acid to give a salt and water only.

(c) This salt is used for flavouring.

(d) Formation of a salt from calcium hydroxide and sulphuric acid is usually disturbed by the insoluble salt thus formed.

19. Some liquid solutions conduct electricity.

    (a) Water may not be a good conductor of electricity.

    (b) Explains why acid solutions are used in batteries.

    (c) When these liquids and solutions conduct electricity, they are decomposed by the electric current.

    (d) Copper sulphate solution is an example.

20. Pure water is colourless, tasteless and boils at 100°C at normal atmospheric pressure.

    (a) It also freezes and melts at 0°C.

    (b) Pure water is necessary with food for all human beings.

    (c) Impure water may boil or freeze at a higher or lower temperature.

    (d) This occurs when the liquid water is in equilibrum with its gaseous form.

APPENDIX V

COGNITIVE PREFERENCE TEST USING DIT APPROACH

THE CHEMISTRY TEACHER

1. Peter, the Chemistry Teacher incharge of form IV believes in asking his students of their previous knowledge on a topic before introducing a new one. This morning, Peter came into the class and said "Today we are going to consider the fractional distillation method of separating mixtures of liquids. Can anybody tell me what he knows about this method?" Below are some of the responses he received:
   (a) The two liquids involved must have different boiling points.
   (b) It is possible to separate two liquids using this process.
   (c) The process explains how petrol is obtained from crude oil.
   (d) More than two liquids can also be separated.

HARDNESS OF WATER

2. A State Government decided to open a new Secondary School in a local government area in the State. The school was cited very close to a river which made water table not too deep and a borehole was sunk for the students usage. The students had the option of using either well or river water for their washings.

But very soon, they discovered that whenever they used 'well water' for their clothes, it did not readily form lather as the river water. So they concluded the well water must be 'hard water'. Some of the students also said:

(a) The presence of soluble metallic salts like hydrogen carbonates (bicarbonates) sulphates and chlorides of calcium, magnesium and iron will prevent the formation of lather with soap.

(b) One type of hardness is temporary.

(c) Hard water is desirable in beer industry.

(d) Hard water may be softened.

ATOMIC STRUCTURE

3. Gladys has been given a homework to draw the former coins and currency before the change to Naira and Kobo. After finishing the drawing, she brought it back to the hostel to show her college mother and mates if there are still others to be included. The very first diagram Gladys had was as follows:-



representing the former one penny. Looking at this critically, the College Mother said "this first one reminds me of the two shells involved in the electronic structure of oxygen". Her other mates also responded saying:-

(a) Oh yes, Oxygen atom has eight elections.

(b) The electronic structure of the oxygen atom determines the reactivity of this atom.

(c) With one electron added to that of the oxygen atom, the electronic structure of another gaseous atom may be deduced.

(d) Oxygen is in the 2nd period so the K shell is full with 2 electrons. Also it is in the 6th group, therefore there are six electrons in the K Shell.

BOYLES LAW

4. Seyi was trying to pump some air into his flat bicycle tyre using a bicycle pump. "Do you know what I've noticed" he said to his friends "the more pressure I apply, the more compressed the volume of the gas. I mean that at this temperature, the volume decreases as pressure increases". His friend each replied as follows:-

(a) That is a statement of Boyle's Law.

(b) This explains why a balloon floats in the air,

(c) When the volume decreases, intermolecular distances decrease and the rate of bombardment on the sides of the container increases.

(d) One wonders if the addition of more gas to a fixed volume of gas at a given temperature would also not increase the pressure.

THE KIPP'S APPARATUS

5. Four form IV students had just been transferred from one Federal Governments College, to another. During the chemistry practical period, the teacher decided to introduce these students to the set up in the laboratory. Coming to the extreme end of the laboratory and at a corner is the kipps apparatus unit. The Teacher said "Well, you may have been used to the kipps apparatus where hydrogen sulphide gas is prepared in quantity". Each of the students responded:-

   (a) Oh yes, Iron II sulphide and dilute Hydrochloric acid are the required chemicals for the reaction.

   (b) The gas may be used to prepare a series of salts known as sulphides.

   (c) This generator can be used to prepare in large quantity any gas which is made from a solid and a liquid in the cold.

   (d) Other regularly used gases in the laboratory can also be prepared using this apparatus.

CANDLE WAX

6. There was no light in the school for the students to do their night studies and only a few students could afford buying candle sticks. Others then decided to go about collecting the candle wax of those who had candle sticks. As it cooled, it solidified and it was

molded up, putting a long thread in the moddle, they had their own sticks to use! One of the students involved said "This means there could be a change of state which is usually reversible. Others replied:-

(a) Yes, it is called a physical change.

(b) It explains why when water is cooled it freezes to ice and when ice is heated, it changes back to water.

(c) Rusting of iron is not a change of this type.

(d) The change in state involves changing from solid to liquid to gas.

WRITING OF EQUATION

7. For the past 3 weeks, the form II Chemistry class has been practising how to write formulae of compounds by identifying the different symbols and valencies of the elements involved. Today, they are moving a step further to writing of equation - which is a convenient method for representing a chemical change using the formulae and symbols they've learnt.

"Let's attempt to write the reaction of zinc with any dilute non oxidisingacid e.g. sulphuric acid" the teacher said. Before he continued, these are the reactions he got from his students:

(a) All metals above hydrogen in the electro-chemical series theoretically react with dilute non-oxidising acid to produce hydrogen.

(b) Hydrogen is produced.

(c) Peanut and coconut oils may be "hardened" when hydrogen gas is blown into them.

(d) Some other metals should similarly react with all dilute non-oxidising acids to produce the same type of gas.

A DELIQUENSCENT SUBSTANCE

8. Ibrahim came back home from the football field with his other friends. Being tired, they decided to sit on the mat outside for their super. Ibrahim's junior sister brought some rice and stew in a big plate for them all. On tasting it, they asked for some salt. The salt was brought to them in a small plate and they took some and left the rest aside. A couple of hours later, one of them noticed that the plate of salt was still outside. He picked it up and observed that the salt has absorbed some water as a result of exposure to air. He called the attention of others and below were some of their comments:

(a) This is a deliqueescent substance.

(b) Air contains water vapour which this salt absorbs because of evaporation of lakes, oceans, seas and rivers.

(c) This explains why pellets of sodium hydroxide kept outside in a watch glass appear to have melted.

(d) Hygroscopic substances also absorb moisture from the atmosphere.

GASES

9. The Form II students are out first thing this morning for physical education (P.E.). Oni, the P.E. Master asked the students to start the morning exercises by breathing in and out as much air as they could. During this exercise, he explained to them that by breathing in, they take in the gas, oxygen and out, carbon dioxide, which shows that air contains more than one gas. Some other students in the play group wanting to display their knowledge of General Science said:

(a) Nitrogen has the greatest percentage.

(b) Air also contains impurities.

(c) Most of the gases are useful to plants and animals.

(d) Air is a mixture and the properties of air are determined from the sum of the properties of the gases.

THE ALLOTROPES OF CARBON

10. It was getting to six o'clock this evening and some students decided to go for a stroll around the staff quarters. A few yards from where they started, Jide picked an engagement ring with a diamond stone. They all stopped and had a look at it in turn. "Diamond and

Graphite" said Yomi are the free state in which carbon occur. Others replied:

(a) They are called the allotropes of carbon.

(b) They are the two different physical forms of carbon but with the same chemical properties.

(c) Diamond is attractive and in a great demand for jewelry.

(d) There are other non-metals, such as sulphur which exist in free states.