



Correlational Analysis between Heath's Cognitive Preference Styles and Chemistry Achievement among Secondary School Students in Niger State, Nigeria

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ABSTRACT

This study investigated correlation between heath's (1964) model of cognitive preference styles and chemistry achievement among secondary school students in Minna educational zone, Niger state, Nigeria. Research design for this study was ex-post facto design. A total of 269 SS3 chemistry students were sampled from randomly selected schools with a total population of 7,414 students. 2 instruments were used for data collection: Heath cognitive preference test instrument (HCPT) with reliability co-efficient of 0.739 and chemistry achievement record scores (CARS) of 2nd term examination organized and supervised by Niger state ministry of education, 2011/2012 session. The data collected were analyzed to answer a research question and a null hypothesis using mean, standard deviation and Pearson product moment correlation statistics. The findings of the study revealed: (i) that recall cognitive preference style is the most prevalent of the four cognitive preference styles identified by Heath (1964) among senior secondary school chemistry students (ii) students' preferences of cognitive styles are not significantly correlated with their achievement in chemistry. Based on the findings of this research, some recommendations were offered among which are; (i) the need for classroom teachers to identify cognitive preference styles of their students so as to present learning materials with respect to students' preferred cognitive styles for positive learning experience and also for the purpose of homogenous or heterogeneous classification of students based on cognitive styles; such classifications may be utilized in the classroom for setting up an affective learning community for efficient teaching and learning of chemistry in particular and science in general.

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INTRODUCTION

When declining performance in science is defying several novel instructional strategies, all science teachers and educators are thus faced with the problem of organization of instruction in such a way as to facilitate learning for majority of the students and to aid positive lateral transfer of knowledge. Sotayo (2007) pointed out that definition, reciting of factual knowledge and memorization are not science learning. Adeyemi (2004) opined that acquisition of science concepts and skills depends much on the way they are taught and learned. Onwukwe and Onwukwe (2010)

stressed that students tends to memorize facts and principle most of which they do not understand, only to regurgitate them during examination. She therefore said that relation of ideas, facts and principles learned in this way might not be worthwhile for learning of science. She defines science as an investigatory enterprise in which certain processes used in investigation should be identified and practiced. She stressed that teaching for understanding should embody more than simple recall of factual information.

WAEC (2003) and NECO (2005)
Chief Examiners' Report in Mogbo (2007)



suggests that one of the factors that may cause the preponderance low achievement in sciences may be related to students' wrong and ineffective learning styles. Grigorenko (2000) in an experimental (alpha testing) setting to determine if a cognitive styles approach might be valuable in the kind of non-laboratory setting (beta testing) where system dynamics and flight simulators are traditionally used. Results indicated that people, who score higher on the abstract component of the Gregore cognitive test, do have a significantly higher propensity to score well on the Kondratiev flight simulator.

The result of Bawa (2011) when he tested the effects of problem solving instructional strategy on academic achievement and retention in ecology among secondary school students with different cognitive preference (Heath, 1964 model) showed significant main effect of problem-solving instructional strategies but did not indicate interaction effect of cognitive preference on the posttest achievement results in any of the preference styles.

The separate studies of John (2011) and Eleni and Norman (2006) reported a significant relation between cognitive styles and Biology, and Chemistry achievements respectively. In a similar development, the study by Atwood (1966) on comparative study of Achievement in Chemical Education Material Study (CHEMS), students classified on the basis of choices on a cognitive preference examination reported that students with strong preference for memory of specific data were at a disadvantage in the CHEMS course relative to those showing strong preference in the other three areas. Also, a strong preference for practical application in combination with fundamental principles or critical questioning of information correlated positively with achievement.

In another research by Tamir (2006), no relationship could be detected between cognitive preferences and sex and only weak correlation were found, with achievement. The major finding of Tamir (2006) was the correlation between major field of study and career expectation with cognitive preferences in the anticipated direction. The "utility" (i.e. practical application mode) and "curiosity" (i.e. critical questioning mode) scales found in earlier studies were confirmed, this time across

three disciplines chemistry, biology, and medicine. The claim that cognitive preferences in science are no more than expressions of levels of cognitive operation as described by Bloom's Taxonomy was not supported. Zero correlations were found between cognitive preferences and cognitive abilities.

In factor analysis, cognitive abilities emerged as a separate factor. On the other hand, consistent interrelationships were found among the cognitive preference areas. It was concluded that cognitive preference are not expressions of cognitive abilities and that they represent a different dimension – belonging not to the 'can do' but rather to the 'does do' type of objectives.

Denigs (2004) concludes that "cognitive styles, by embracing both perceptual and intellectual domains, "promise to provide a more effective characterization of the students that could not be obtained from intellectual tests alone" (p.101). He also suggest that cognitive styles appear to be particularly important dimensions to assess for educational purposes since they can provide a basis for improved instructional practices such as "matching the student to the teacher and the teaching method" or the fostering of alternative modes of cognition and stylistic approaches to problem solving". The study by Eleni and Norman (2006) on cognitive factors that can potentially affect pupils' test performance revealed that convergent/divergent characteristics correlated with pupils' performance in assessment where language was an important factor but not in algorithmic types of questions or in a question where there is a greater use of symbols and less use of words. He observed that, it seem that, in relation to the convergent/divergent characteristic, the chemistry content and presentation of the test is a factor affecting the type of questions being asked. The study then suggest that some of the factors that affect pupils' performance might be

- (a) The content and presentation of the test
- (b) The formation of the test
- (c) The psychology of the individual.

Furthermore, the study of Sotayo (2007) on Computer Assisted Programmed Instruction and Cognitive preference style as Determinant of Achievement of Secondary



School Physics Students revealed a positive correlation between cognitive preference style and achievement. Achievement of students of application learning mode was significantly higher than those of recall and principle respectively. The study also revealed a significant interaction effect between cognitive preference style and Computer Assisted Programme Instruction. Similarly, Sam, Grace and Udida (2006) reported significance in student academic performance in chemistry due to their cognitive styles. Students with analytic cognitive styles performed significantly higher than relational and inferential. Al-Naeme's (1988) research showed that divergent students had higher scores than convergent students in mini projects in chemistry. However, Bahar and Hansell (2000) showed that divergent pupils/students did not perform better in all cases compared to convergent pupils/students. Thus, they suggested that, when one is looking at the relationship between students' performance in any topic and their cognitive styles, the type of assessment techniques used, such as multiple choice type of questions, essay questions, projects and so forth should be reported because a particular type of assessment technique may favour a particular kind of cognitive style. Different types of instructional strategies and assessment seem to encourage deep or surface approaches to learning (Struyven, Dochy & Janseen 2002).

A causal model proposed by Aghadiuno (2006) in order to explain secondary students' achievement in chemistry are; students' attitude towards chemistry, understanding world-view, cognitive style, teachers' attitude towards the teaching of chemistry and understanding of science. Some 460 students chosen by means of stratified cluster sampling and their 25 teachers make up the student and teacher samples, respectively. The numerical values of all the variables are obtained and their inter-correlations, the coefficients of the structural equations of the proposed hypothesized model is tenable. Of the seven predictors; variance in the cognitive style account for 21.69 of the variance in the criterion; their indirect effect is 8.4%.

Zhang (2004) examined the nature of field independent-dependent construct against academic achievement as well as thinking style

as defined in Sternberg's theory of mental self-government. Participants responded to the group embedded figure test and the thinking style inventory. Student's academic achievement was examined in relation to field independent- dependent and thinking style score. Major findings were that field independent- dependent and thinking style construct were unrelated, particular thinking styles were related, but to the students overall achievement in mathematics course.

Charles (2000) investigated the cognitive styles, achievement scores and attitude toward computer among university students and found that there was no significant relationship between cognitive style and attitude towards computer. Gee Tanjali (2006) studied the academic achievement in relation to cognitive style and hemispheric style at secondary stage and found that cognitive style had significant effect on students' achievement.

Kent (2009) made an investigation of cognitive style, learning style and study skills as predictors of academic achievement of prospective teachers and found that examination mastery along with cognitive style and imaginative style was found to be a good predictor of academic achievement.

Kirk (2001) in Silver (2001) investigated the relationship of attitude towards science, cognitive style and self-concept to achievement in chemistry at the secondary school level. Results indicated that field independent was significantly correlated with problem solving, academic and laboratory achievement, better attitude towards the sciences and problems accompany scientific progress which was significantly correlated with higher achievement on all the academic measures of chemistry.

Recent researches on students' academic achievement have taken the form of finding human or environmental variables which correlate with high achievement and which can be used as predictors of achievement. Among the various variables identified are individual differences (Pitcher, 2002). Different researchers emphasized different dimensions of individual difference which correlate with higher achievement and hold out some hope for positive action for educational practice (Stephen, 2002). Of these dimensions, cognitive preference styles and



students attitude are major ones. This study focuses on learner characteristics that are concerned with conceptualization of cognitive learning. This characteristic is cognitive preference style. This is particularly important because science learning is becoming increasingly conceptual (Maduabum & Odili, 2006).

Unfortunately, "throughout the world science is witnessing a decline as science departments are closed down" (Main, 2005:p.7). This is happening when the whole world is yearning to train more scientists, especially the physical scientist. According to Ukor (2010), Nigeria is in danger of a declining population of scientists, noticeable in yearly poor performance of students at the SSCE in the sciences (Ada, 2003, WAEC Chief Examiner's Report, 2005 in Ukor (2010). This problem has attracted the attention of many researchers (Farayola, 2003 and Abdullahi, 2004). Some of them have identified the source of the problem to include, among others, the use of lecture method, lack of teaching facilities, incompetent teachers, poor funding, abstract and numerical natures of science concepts etc (Obodo, 2004; Ibe, 2004; Nnaobi, 2004 and Ukar, 2006.). Despite the fact that chemistry is very central to the study of all science courses, the subject is associated with low students enrolment and performance (Njoku, 2007).

Chemistry is also directly related to other natural sciences such as physics and biology. Hence, the encouragement of the learning of chemistry especially at the senior secondary school level is of paramount importance and one way by which this can be achieve is through the understanding of varying cognitive preference styles of chemistry students and how such cognitive preference style can influence chemistry achievement in secondary schools.

Purpose of the Study

The purpose of the study is to determine the effects of Heath's cognitive preference styles on chemistry achievement of secondary school students.

The study strived to achieve the following objectives:

- i. Examine the most prevalent of Heath's cognitive preference styles among chemistry students of public

senior secondary schools in Minna Educational Zone, Niger State.

- ii. Assess the effect of Heath's cognitive preference styles on chemistry achievement of public senior secondary school students in Minna Educational Zone, Niger State.

Research Questions

- i. Which of Heath's cognitive preference styles is most prevalent among Chemistry Students of Public Senior Secondary Schools in Minna Educational Zone of Niger State?
- ii. Is there any significant relationship between Heath's cognitive preference styles and chemistry achievement of subjects of this study?

Null Hypothesis (Ho)

Ho: There is no significant relationship between Heaths' cognitive preference styles of chemistry students and their achievement.

METHODOLOGY

The research design used was ex-post fact design. The effect of the independent variable (cognitive preference style) on the dependent variable (chemistry achievement) already exist. Therefore, no effort to manipulate or count them was required. The study only traced possible relationship between the variables. A total of 7, 414 senior secondary three (SS3) chemistry students in public schools of four local government areas of Minna educational zone of Niger state formed the population of the study. Five of the schools are pure girls, one pure boys school, while the remaining thirty two out of total thirty-eight schools were a mixed of boys and girls schools. A total of 269 SS3 chemistry students were sampled from randomly selected 7 intact classes among the 7 randomly selected schools. Intact classes were deliberately used, so as to ease collecting and collation of previous chemistry achievement records of subjects of study.

Two instruments were used for data collection: heath cognitive preference test instrument (HCPT) with reliability co-efficient of 0.739 and chemistry achievement record



scores (CARS) of 2nd term examination (MOCK SSCE) organized and supervised by Niger state ministry of education, 2011/2012 session. The (CARS) scores were collected from examination office of each selected schools, while HCPTs comprised of 40, 4-option objective questions and student's and personal bio-data. Each of the options is correct option to the main stem question but only reflecting one of the heath's cognitive preference styles. The students are expected to choose the one that first appeal to them or most preferred by them.

RESULTS

Research Question: Which of Heath's Cognitive Preference Styles is most prevalent among Chemistry Students of Public Senior Secondary Schools in Minna Educational Zone of Niger State?

Four types of cognitive styles identified by Heath (1964) were investigated. These were R_1, P_2, Q_3 and A_4. Their aggregate sum was computed as the cognitive styles which constituted the major variable for the study. The mean scores of the variables along with the standard deviations and standard errors are presented in Table 1.

Table 1: Mean and Standard Deviation of Cognitive Preference Styles and Achievement of Students in Chemistry.

Variables	N	Mean	Standard deviation	Standard. Error
R_1(recall)	269	13.25	4.379	.267
P_2(principle)	269	11.30	3.747	.228
Q_3(questioning)	269	7.38	2.672	.163
A_4(application)	269	7.32	5.959	.363
Chemistry Achievement Record Scores (CARS)	269	57.84	13.876	.846
Total Score In Heaths' Cognitive Preference Styles (HCPT) Score	269	39.239	6.31593	.38509

The table 1 above revealed that R_1 (recall) cognitive style was scored highest among the four cognitive styles. Next in the hierarchy were Principle and questioning with application being the least scored by the students. In order of prevalence, recall as one

of the Heaths' cognitive preference style was the most prevalent.

Hypothesis (H₀): "There is no significant relationship between Heaths' Cognitive Preference Styles of Chemistry Students and their Achievement in Minna, Educational Zone of Niger State."

Table 2: Correlation between Preferred Cognitive Styles and the Achievement of Students in Chemistry

Variables	R_1	P_2	Q_3	A_4	Achievement	Cognitive
R_1	1	-.425(**)	-.373(**)	-.160(**)	-.112	.133(*)
P_2	-.425(**)	1	-.118	-.034	.079	.216(**)
Q_3	-.373(**)	-.118	1	-.034	.098	.063
A_4	-.160(**)	-.034	-.034	1	.030	.798(**)
Achievement	-.112	.079	.098	.030	1	.039
Cognitive	.133(*)	.216(**)	.063	.798(**)	.039	1
	269	269	269	269	269	269

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

r-critical=0.113 at P=0.05 level



Table 3: Summarized Pearson Correlation Matrix Between Cognitive Preference Style and Achievement of Chemistry Students.

Variables	N	X	S.D	S.E	df	P	r-value	Remarks
Achievement	269	57.84	13.876	0.846	267	0.525	0.039	Not sigs
Cognitive	269	39.239	6.316	0.385				

$p \geq 0.05$ NS: Not significant at 0.05 level

The result of the test in the table 2 above revealed that the preferred cognitive styles are not significantly correlated with the students' achievement in chemistry in the selected senior secondary schools. The observed correlation coefficients for each of the preferred cognitive styles with chemistry achievement (Table 3) are not significant ($p \geq 0.05$ sig. level). This means that the null hypothesis that there is no significant relationship between cognitive styles of chemistry students and their achievement using Heaths' (1964) cognitive model cannot be rejected. The result of the test revealed that the students' cognitive preference have no impact on their performances in chemistry. However, the test revealed that preference of recall (R_1) is significantly correlated with the preferences of Principle (P_2), questioning (Q_3) and application (A_4). But there was no significant relationship between preferences for Principle (P_2), Questioning (Q_3) and Application (A_4) (Table 2).

DISCUSSION

From the analysis of the four cognitive preference styles identified by Heath (1964) using descriptive statistics (Table 1). It was observed that R-1 (recall) cognitive style was scored highest among the four cognitive preference styles. This finding answered the research question. It is empirically established that the most prevalent of Heath's cognitive preference style among chemistry students is the recall (R-1) style.

From the result of hypothesis tested in this study, it was the general observation that preferred cognitive styles of chemistry students do not necessarily have significant correlation with their academic achievement in chemistry. The null hypothesis was therefore retained. Further observation revealed that preference for the recall cognitive style was significantly correlated with the expressed preference for principle, questioning and

application cognitive styles. But the cognitive styles of principle, questioning and application were not significantly correlated. This finding is in agreement with Tamir (2006) who opined that cognitive preference styles are not expression of cognitive abilities, and that they represent a different dimension-belonging not to the "can do" but rather to the "does do" type of objectives. In the report it was argued that intellectual abilities are primarily concerned with the ability to learn while cognitive styles are primarily concerned with differences in the ways of learning. This finding is also in agreement with findings of Bawa (2011) when he tested the effect of problem solving instructional strategy on Academic Achievement and Retention in Ecology among secondary school students with different cognitive preferences using heath (1964). His findings revealed only main effect of problem solving instructional strategy but did not indicate interaction effect of cognitive preferences on posttest achievement results in any of the preferences i.e. preferences of recall, principle, questioning and application modes. Egolum (2012) also reported no significant interaction effect of concept mapping teaching method and cognitive style on mean achievement scores of subjects of the study. The result of this finding contradicts the findings of Saracho (1980), Okebukola (2002). Saracho (1980) found a significant gain in achievement (field independent) over field-dependent) among Basic Science Students. Regina (2011) found significant main effect of cognitive style on student's academic achievement. Johari (2004) also established relationship between cognitive styles and achievement in chemistry.

The findings of James, Michael and Scott (2000) using three different cognitive style instruments (i.e. MBTI, Gregore Style Delineator and Gordon Cognitive Style Indicator) revealed that none of the three cognitive styles tested could explain



performance in flight simulation game at any reasonable level of significance.

CONCLUSION

Based on the findings of this investigation, this study can be concluded thus;

- 1- Recall cognitive preference style is the most prevalent of the four Cognitive Preference Styles identified by Heath (1964) among senior secondary school chemistry students of Minna Educational Zone of Niger State (Table 1).
- 2- Students' preferences of cognitive styles are not significantly correlated with their achievement in chemistry (Table 3).

RECOMMENDATIONS

Based on the findings, the following recommendations are presented:-

1. Effort should be made by teachers to identify cognitive styles of students at least for the purpose of homogeneous or heterogeneous classification (as the situation requires) of students based on their cognitive preference style; such classifications may be utilized in the classroom for setting up an effective learning community for efficient teaching and learning of chemistry in particular and science in general.
2. This study revealed that students varied in the way they perceived and process information, therefore, the teacher has to take into consideration student's cognitive styles so as to present learning materials in a way that will enhance student's performance.
3. The result of this research revealed that recall Cognitive Preference Style is the most prevalent among the subjects of this study. However, unfortunately recall from memory of material learned is not good for science learning. Therefore there is need for teachers to make deliberate effort to re-orientate

cognitive style of chemistry students in particular and science students in general towards cognitive styles that will favour science learning, for instance, Questioning and Practical application modes.

4. Science teachers in general and chemistry teachers in particular are advised to foster alternative modes of cognition and stylistic approaches to problem solving, making a shift from recall cognitive preference style; which is not effective for science learning to other cognitive preference styles that support learning of process skills like questioning and practical application cognitive preference modes.

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