THE RELATIONSHIP BETWEEN COGNITIVE PREFERENCES AND ACHIEVEMENT IN BIOLOGY

Dr. Clement O, Abah

Abstract

This study examined the relationship between students' cognitive preferences for Recall, Principles, Application and Questioning, and their achievements in biology cognitive tasks set at the corresponding levels of Knowledge, Comprehension, Application and Analysis of Bloom's Taxonomy respectively. Two instruments were developed to measure the variables of the study. Data analysis was undertaken by means of the Pearson product-moment coefficient of correlation and multiple regression. The findings showed no significant positive relationship between any particular mode of preference and achievement in the corresponding level of cognitive task. Rather, preferences for Recall and Questioning were found to have a significant positive influence on achievement in a non-corresponding level of cognitive task. This among others, suggests that the manner in which cognitive preferences influence achievement is broad-based rather than restrictive.

Introduction

The cognitive preference construct originally proposed by Heath (1964) is an idiosyncratic mode of information processing which places emphasis on what an individual is likely to do with information intellectually. For example, when a student is presented with scientific information, he may attend to such information in any of the following ways:

(i) Memorize the facts contained in the information (= Recall)
(ii) Focus on the fundamental principles that underlie the information (= Principle),
(iii) Dwell on the practical applicability of the information in a general, social, or scientific context (= Application).
(iv) Question the information critically (= Questioning).

Heath (1964) regards the tendency to focus on any of the above aspects of a given scientific information as a personal attribute which he described as "cognitive preference."

Since the first proposition of the cognitive preference construct by Heath, its significance in the field of science education has been extensively researched. Although many studies related students' cognitive preferences for "recall," "principles," "application" and "questioning" to overall scores on the test of academic achievement, only Tamir (1977) and McNaught (1982) tried to relate these cognitive preferences to achievement test questions set specifically at corresponding cognitive levels of Bloom's Taxonomy (1956).

While Tamir related the four cognitive preferences to achievement at Bloom's cognitive levels of "Knowledge", "Comprehension" and "Higher Abilities", McNaught related them to achievement at Bloom's cognitive levels of "Knowledge" and "Higher Abilities." By grouping achievement test questions at the levels of "Higher Abilities" together, neither Tamir nor McNaught could be said to have exhaustively established the relationships, if any, between the four cognitive preference areas and achievement at the four corresponding levels of Bloom's Taxonomy, namely "Knowledge", "Comprehension", "Application" and "Analysis". Moreover, in his studies, Tamir (1977) found no relationship between cognitive preferences for "recall", "principles", "application" and "questioning" and achievement at Bloom's cognitive levels of "Knowledge", "Comprehension" and "Higher Abilities" McNaught (1982) on the other hand, reported a "strong relationship" between cognitive preference for "principles" and achievement at the "Higher than knowledge" level of Blooms' Taxonomy. Thus, apart from inexhaustive examination of all possible relationships, the findings of Tamir and McNaught show elements of contradiction.

In the light of the above, the present study was designed to further clarify these relationships by testing the following null hypotheses:

Ho: 1: Students' cognitive preferences for recall of facts and terms do not relate significantly and positively to their scores in achievement test questions calling for recall of facts and terms.

Ho:2: There is no significant positive relationship between students' cognitive preferences for fundamental principles and their scores in achievement test questions based on comprehension of fundamental principles.

Ho:3: Students' cognitive preferences for practical application of knowledge do not relate significantly and positively to their scores in achievement test questions calling for application of knowledge.

Ho:4: There is no significant positive relationship between students' cognitive preferences for critical questioning of information and their scores in achievement test questions based on analysis of information.

Methods

The study samples were drawn randomly from a population of 250 fresh biology students of a School of Basic Studies, registered just after completion of secondary school education. Two separate samples were drawn. One made up of 24 students (9 girls and 15 boys) selected from a population of 50 students who were exposed to CESAC Biology Syllabus in their secondary schools. The other sample comprised 60 students (20 girls and 40 boys) selected from a population of 200 students who were exposed to Traditional Biology Syllabus in their secondary schools. Subsequent data analysis in respect of the two samples was done separately because both syllabuses have different philosophical orientations (Ivowi, 1982 a & b) which may affect the general pattern of cognitive preferences of students as well as the relationship between their cognitive preferences and achievement.

The cognitive preferences of students were measured by the "Cognitive Preference Test in Biology" (CPTB) while achievement at four levels of cognitive tasks was measured by the "Cognitively Structured Achievement Test in Biology" (CSATB). Both instruments were constructed by this researcher.

The Cognitive Preference Test in Biology (CPTB) is a 40-item test based on the model of Heath (1964). Each item consists of a stem in the form of a statement or diagram or some biological information, followed by four options lettered A, B, C and D. Each of the four options is biologically correct in relation to the information in the stem and exclusively demonstrates one of the four modes of cognitive preference (Recall, Principle, Application, Questioning).

The items of the CPTB were scored by the graded rating procedure proposed by Kempa and Dube (1973) and used extensively in literature. By this procedure students were asked to rate the four options of each item in order of preference by awarding four points to the most preferred option, three points to the next preferred, two points to the next, and one point to the least preferred. Thus, the lowest possible score on any of the four options would be 40 and the highest possible score would be 160.

The Cognitively Structured Achievement Test in Biology (CSATB) is a 32-item multiple choice test with four options, of which one is the correct answer and the other three served as distractors. The items represent cognitive tasks at the levels of "Knowledge", "Comprehension", "Application" and "Analysis" of

Bloom's Taxonomy (1956). There are eight items at each cognitive level. Subjects were requested to indicate the correct answer in each case. Scores were arranged into four scales, one for each cognitive level. The minimum possible score at each level is zero and the maximum is eight.

To ensure validity, the subject matter of all items of both the CPTB and CSATB were drawn from within the context of CESAC and Traditional biology syllabuses. Only subject matter commonly treated by both syllabuses were included in the items of the two instruments. Also, the initial pool of items of both instruments were submitted to a panel of experts for their authoritative judgement. A university professor and a senior lecturer in biological sciences as well as a senior lecturer and a lecturer in science education (both with biology background) were requested to ascertain whether or not the information included in each item of each instrument was consistent with currently accepted biological knowledge.

In the case of the CPTB they were also requested to examine whether or not the keying of the options under each item to the four cognitive preference modes (recall, principle, application and questioning) was appropriate. For the CSATB, they were further requested to determine whether or not each question properly belongs to the level of Bloom's Taxonomy (1956) to which it was assigned. Initial items which enjoyed the unanimous agreement of all judges were selected, while those that did not were revised till they did so. Furthermore, two secondary school biology teachers with over five years of teaching experience certified that the contents of the items of each instrument were relevant and comprehensible to students exposed to either CESAC or Traditional biology syllabus.

The split-half reliability estimates of the CPTB and the CSATB were computed by means of the Pearson product moment coefficient of correlation and adjusted by the Spearman Brown formula. The figures obtained in respect of the CPTB on Recall, Principle, Application and Questioning respectively were .86, .86, .93, .82 (for CESAC syllabus sample) and .94, .86, .86, .90 (for Traditional syllabus sample). In respect of the CSATB the reliability estimates were .90 (for CESAC syllabus sample) and .91 (for Traditional syllabus sample). These figures were considered to be adequate evidence of the reliability of the two instruments.

Findings

The means and standard deviations of the scores of the two samples of subjects on the four modes of cognitive preference as well as on the four levels of achievement of cognitive tasks were computed. For the CESAC syllabus sample, the mean scores on Recall, Principle, Application and Questioning modes of cognitive preference were 88.96, 128.33, 110.33 and 72.67 respectively, while the standard deviations were 10.26, 10.85, 14.70 and 12.23 respectively. For the traditional syllabus sample, the mean scores were 100.52, 130.20, 101.12 and 67.85 while the standard deviations were 16.70, 11,69, 13.97 and 11.75 on the Recall, Principle, Application and Questioning modes of

cognitive preference respectively. The mean achievement test scores of the CESAC syllabus sample on the cognitive levels of Knowledge, Comprehension, Application and Analysis respectively were 4.58, 5.83, 5.42, 4.58, with standard deviations of 1.47, 1.27, 1.06 and 1.69. For the traditional syllabus sample, the mean achievement test scores were 4.78, 6.02, 5.68, 4.25 with standard deviations of 1.26, 1.32, 1.61, 1.77 on the cognitive levels of Knowledge., Comprehension, Application and Analysis respectively.

In order to test the hypotheses of the study, subjects' scores on each of the four levels of achievement were correlated with their scores on each of the four modes of cognitive preference. The resulting Pearson product-moment coefficients of correlation for the two samples are shown in Table 1. None of the correlation coefficients reported in Table 1 was significant at the 0.05 level, hence none of the null hypotheses of the study was rejected.

Table 1: Pearson Product Moment Correlations Between Cognitive Preferences And Levels Of Achievement

Level of Achievement	Cognitive Preferences			
CESAC Syllabus	Recall	Principle	Application	Questioning
Knowledge	-.019	.039	-.118	.154
Comprehension	-.174	.073	-.378	.320
Application	.178	-.115	-.205	.300
Analysis	.079	-.061	-.043	.081
Traditional Syllabus				
Knowledge	-.089	.109	-.088	-.091
Comprehension	-.098	.189	.001	-.084
Application	-.048	.178	-.049	-.037
Analysis	.102	.097	-.025	-.213

A further attempt was made to determine the degree of dependence of each level of achievement on each of the four modes of cognitive preference after any possible interfering effects of the latter on one another will have been partialled out. Hence, using subjects' scores on each of the four levels of achievement as dependent variables and their scores on the four modes of cognitive preference as independent variables, a step-wise multiple regression analysis was carried out. The results of this analysis revealed the following:

1. Achievement at the "Knowledge" level was significantly (0.05 level of confidence) but negatively predicted by cognitive preferences for "Recall" and "Application" in respect of the traditional syllabus sample (See Table 2).
2. Achievement at the "Application" level was significantly (0.05 level of confidence) and positively predicted by cognitive preferences for "Recall" and "Questioning" in respect of the CESAC syllabus sample (See Table 3).
3. Achievement at the levels of "Comprehension" and "Analysis" were not significantly predicted by any of the four modes of cognitive preference in respect of any of the two samples.

It may be noted that none of these latter findings still provides any evidence for the rejection of any of the null hypotheses of the study, since the cases of significant predictions are either negative or positive but not between a given mode of cognitive preference and achievement at a corresponding level of Bloom's Taxonomy.

Table 2: Summary Of Stepwise Regression Of Achievement (Knowledge) On The Four

Cognitive Preference Mode	Multiple R	% of Variance Explained(R^2)	Increase in % Variance Explained	F-ratio to Enter or Remove
CESAC Syllabus				
Recall	.0185	0.03	0.03	0.73
Principle	.0529	0.28	0.25	1.12
Application	.1453	2.11	1.83	0.72
Questioning	.2940	8.64	6.53	1.36
Traditional Syllabus				
Recall	.0894	0.80	0.80	5.00*
Principle	.1380	1.90	1.10	0.17
Questioning	.1782	3.18	1.27	1.61
Application	.3205	10.27	7.10	[illegible]

* Significant at .05 level but with negative beta effect

Table 3: Summary Of Stepwise Regression Of Achievement (Application) On The Four

Cognitive Preference Mode	Multiple R	% of Variance Explained (R^2)	Increase in % Variance Explained	F-ratio to Enter or Remove
CESAC Syllabus				
Recall	.1777	3.16	3.16	6.97*
Principle	.2645	7.00	3.84	3.32
	.3594	12.92	5.93	3.64
Questioning	.5971	35.66	22.74	6.71*
Traditional Syllabus				
Recall '	.0480	0.23	0.23	0.46
	,1827	3.34	3.11	0.72
	.1862	3.47	0.13	0.14
	.2004	4.02	0.55	0.31
* Significant at .05 level with positive beta effect.				

Discussion

The fact that the results of the study do not provide evidence for the rejection of any of the hypotheses of the study means that strong cognitive preferences for Recall, Principle, Application and Questioning do not necessarily lead to higher achievement at the specifically corresponding cognitive tasks of Knowledge, Comprehension, Application and Analysis of Bloom's Taxonomy respectively. This finding is in line with that of Tamir (1977) and contrary to that of McNaught (1982). It also disproves, as Tamir (1977) did, the suggestion by Brown (1975) that cognitive preferences for Recall, Principle, Application and Questioning represent no more than preferences for statements implying cognitive behaviour at the levels of Knowledge, Comprehension, Application and Analysis respectively. In fact the significant prediction of "Knowledge" achievement by "Recall" cognitive preference in the negative sense is a strong case against this kind of relationship.

While the one-to-one kind of relationship between cognitive preferences and achievement in corresponding levels of cognitive tasks may not show much promise as discussed above, a new kind of relationship which may be of much educational benefit did emerge in the results of this study. For example, the significant (Positive) prediction of achievement (Application) by Cognitive preferences (Recall and Questioning) show that cognitive preferences do predict achievement in tasks set at non-corresponding cognitive levels. It also suggests that preference for "even" Recall can be of advantage in the performance of certain tasks, and that more than one type of cognitive preference may influence achievement of a particular kind.

• Another issue that did emerge in this study is that the relationship between cognitive preferences and achievement at the four levels of cognitive tasks may depend on the curriculum of study (See Table 1). For example, cognitive preference (Questioning) correlated positively with all levels of achievement in the CESAC syllabus sample but correlated negatively with same in the traditional syllabus sample. Cognitive preference (Principle) correlated positively with all levels of achievement in the Traditional syllabus sample but correlated more on the negative side with the CESAC syllabus sample. Only Cognitive preference (Application) showed a nearly uniform pattern of correlation with achievement in both samples though the values of the predominantly negative correlations are relatively higher in the CESAC Syllabus sample.

Cognitive preferences need not be dismissed with a wave of the hand as predictors of achievement. Apart from the significant positive prediction cases discussed earlier, the positive correlation of "Questioning" cognitive preference with all four levels of achievement among the CESAC sample (though not significant) also underscores the importance of preference tor "Questioning" among science students. All these point to the fact that although most educators would rather see the development of desirable cognitive preferences per se as a major instructional and curricular goal, there is much room for others who would wish to regard cognitive preferences as predictors of cognitive achievement as well. The need for further research therefore abounds.

The findings of this study also have some implications for the cognitive structure of

examination questions. Since students' cognitive preferences (at least in some cases) have been found to have significant influence on their achievement at certain levels of cognitive tasks, it may be proper to suggest that in the setting of examination questions, efforts be made to include test items at all possible cognitive levels of Bloom's Taxonomy (1956) so that students' achievement in such examinations will not suffer due to their peculiar cognitive preferences.

Conclusion

The findings of this study did not produce any evidence of a significant positive relationship between cognitive preferences for Recall, Principle, Application and Questioning and achievement at Bloom's corresponding cognitive levels of Knowledge, Comprehension, Application and Analysis respectively on a one-to-one basis. Rather, preferences for some modes of cognitive preference significantly influenced achievement at non-corresponding levels of cognitive tasks. Also evidence of possible influence of the syllabus of study on the relationship of cognitive preferences and achievement was found. All these suggest that a broad rather than a restricted view be maintained by science educators in this matter of relationships between cognitive preferences and achievement. Such a view should be maintained in curriculum development and the setting of examination questions so as to encourage and exploit the positive relationships to the educational advantage of students.

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